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WELDED RIGID-FRAME FACTORY BUILDING.

By O. BONDY, M.I.Struct.E.

STRUCTURES of the rigid frame type show certain advantages, whether built in timber, reinforced-concrete or steel. In recent years, rigid steel frames have become more popular, and many buildings and bridges of this type have been erected in riveted construction. Their superiority as compared with conventional types of structures has been considerably enhanced by the introduction of welding, the welded joint being rigid by its very nature. Welded-steel structures were erected in the London areas as early as 1920,* but it was not until about 15 years later that welded rigid-frame structures of the statically-indeterminate type were built in this country. Their number and size is still comparatively small.

In 1936, a welding shop of all-welded construction, of 48 ft. span and 300 ft. length, was designed and built for a works in the north of England. Recently, steady increase in output of welded steel platework led to the need for a larger welding shop to replace this earlier structure. The new welding was to be designed for 300 ft. length and approximately 80 ft. span, allowing for two overhead travelling cranes of 20 tons capacity, each working simultaneously, on tracks of 75 ft. span, 30 ft. above floor level. Various types of structures were considered, but in view of the works' many years of experience in welding production there was, from the outset, little doubt regarding the advantages of a welded structure. Before deciding on the most suitable type of structure, however, two designs were prepared in detail, so as to permit a fair comparison of costs. The basis for comparison is indicated in Figs. 1 to 3, on this page, showing the two-pin rigid frame, Design A (Fig. 1), and the conventional type B (Fig. 3), with stanchions restrained at the bottom and latticed roof truss. Both structures were assumed to be welded throughout. The dimension given in Fig. 2 refer to both designs. The stresses and loads allowed for are given in Table I.

The quantities for the two designs are shown in Table II, page 282. The comparison shows that the steelwork for design A (rigid frame) is about 10 per cent. heavier than that of design B. The costs of the foundation, however, including excavation, were about 60 per cent. higher for the conventional design B. Final comparison of costs for the whole building showed a difference of only 150*l.*, in favour of the rigid-frame design A. There were, however, a number of additional advantages in favour of this design. The two-pin frame gave better lateral rigidity, transverse forces from the cranes and wind being partly transmitted through the roof portion of the frame; the solid web structure also had a higher degree of corrosion resistance and lower maintenance costs as compared with lattice work; the clear headroom was greater; easier access to roofing for inspection and repair from inside the building was provided; there was higher daylight intensity due to the roof apex being about 13 ft. nearer to the factory floor than in design B; finally, the finished structure was considered to be of better appearance. Taking all these points into consideration, the works decided in favour of the two-pin rigid-frame design, in all-welded construction.

Fig. 1.

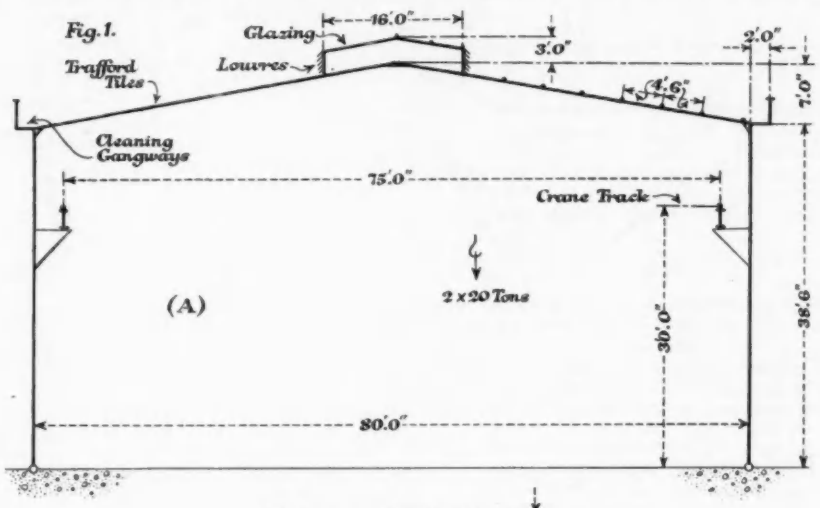


Fig. 3.

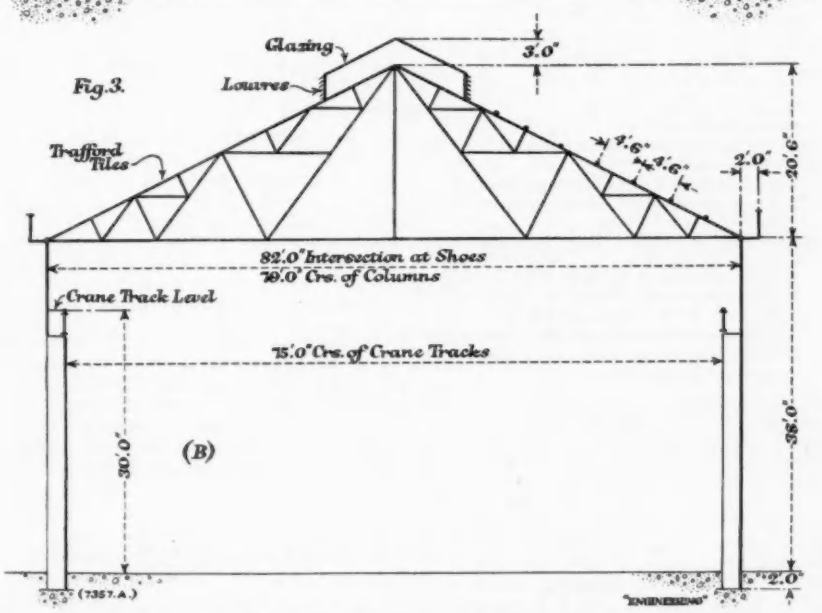


Fig. 2.

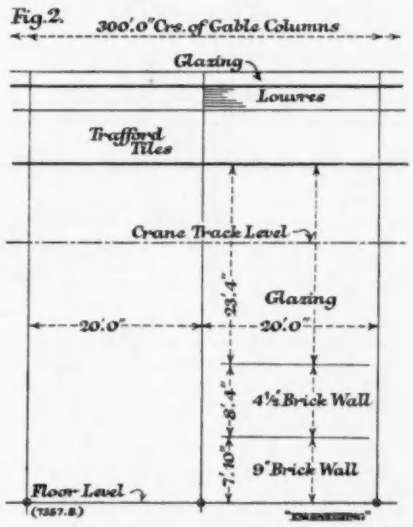
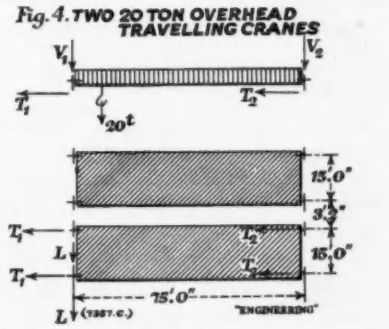


Fig. 4. TWO 20 TON OVERHEAD TRAVELLING CRANES



Rigid-Frame Structure—General.—The subsoil on the site of the new building is a fairly dry clay. Its bearing capacity has been ascertained by practical loading tests and 2·25 tons per square foot was accepted as a permissible pressure. Care had to be taken in designing the foundations, in view of the sensitivity of two-pin frames to horizontal movement of the foundations. Such movement would lead to a redistribution of bending moments over the whole frame and possibly to stresses far in excess of the permissible figures.

Various arrangements for the glazing were investigated so as to give the maximum daylight intensity inside the building. A horizontal plane 3 ft. 4 in. above floor level was assumed as the working level. A total depth of 23 ft. 4 in. for the side glazing over the whole length of the building was accepted. To investigate the effect of moving the side glazing upwards or downwards, daylight intensities were compared, as shown in Figs. 5 and 6, on Plate XX. This method is based on measuring

TABLE I.

Permissible working stress in steel ...	8 tons per sq. in.
Load on subsoil, taking into account weight of foundation block...	2·25 tons per sq. ft.
Dead loads:	
Trafford tiles (roof)	3 lb. per sq. ft.
Glazing (roof and walls)	6 ,, ,,
Brick walls	...112 lb. per cub. ft.
Superimposed loads:	
Roof A, on covered area, acting vertically, including snow and wind...	30 lb. per sq. ft.
Roof B (Duchemin) upon sloping surface, acting at right angles to the slope inwards	23 ,, ,,
Roof B, acting outwards on the leeward side	15 ,, ,,
Vertical surfaces (both designs), including lantern over 13 bays, due to wind acting horizontally ...	30 ,, ,,
Cranes:	
Maximum wheel pressure, including impact by dead and live load, dragging and braking (see Fig. 4):	
(*a*) Vertically, per wheel (max.) ...	V_1 = 26 tons; V_2 = 5 ,,
(*b*) Horizontally, longitudinal ...	L = 3·7 tons
(*c*) Horizontally, transverse ...	T_1 = 2·6 ,, T_2 = 0·5 ,,

* ENGINEERING, vol. 109, page 654 (1920); vol. 111, page 323 (1921); and vol. 113, page 88 (1922).

WELDED RIGID-FRAME FACTORY BUILDING.

Fig. 34.

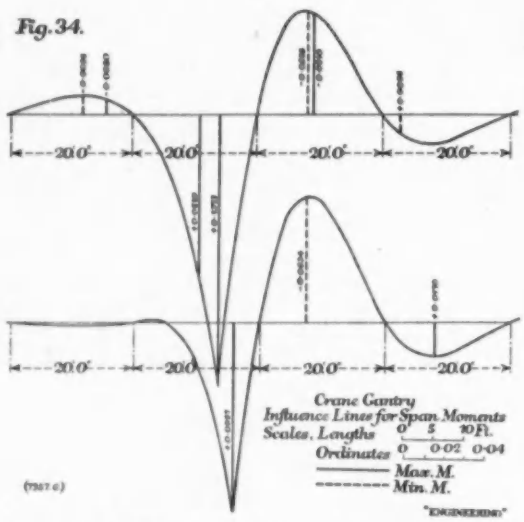
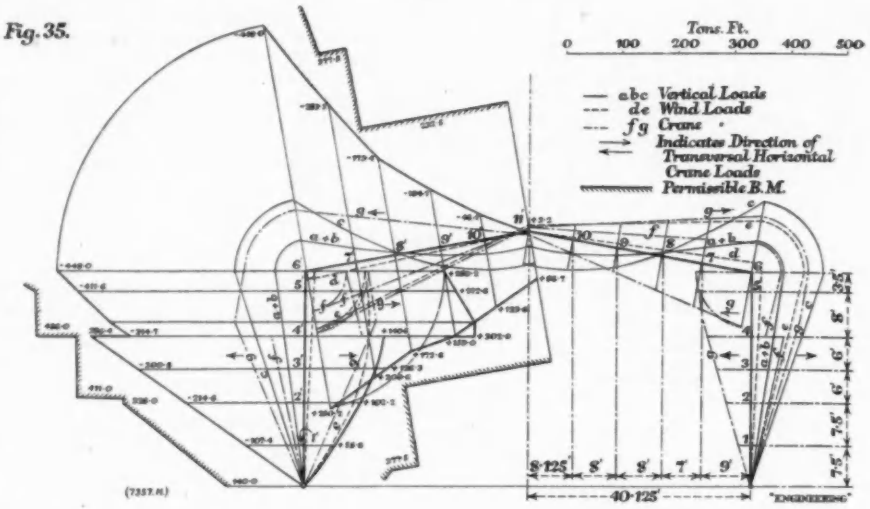


Fig. 35.



the daylight intensity at a given spot inside the building by the angle between the extreme rays from any of the glazed surfaces. The comparison in these figures shows that with the same depth (and cost) of side glazing, the daylight intensity inside the building can be increased up to 16 per cent. The shaded area in Fig. 6 represents the increase in daylight-intensity at a level 3 ft. 4 in. above the floor. An additional advantage as regards daylight intensity results from the fact that the apex of the rigid-frame structure is about 13 ft. nearer to the floor as compared with the conventional roof-truss design B.

Table II.—*Comparison of Quantities for Two Designs.*

Description.	Unit.	Design. A. Rigid Frames.	Design. B. Roof Trusses.	Remarks.
1. Steelwork ..	tons	282·7	258·3	
2. Foundation :—				
Excavation ..	cub. yd.	385	1,075	Permissible pressure on subsoil, 2·25 tons per sq. ft.
Concrete 1 : 2 : 4	cub. yd.	355	476	
Shuttering ..	sq. yd.	175	645	
Steel reinforcement	tons	1	15	

Three different materials for roof covering were investigated. The final choice was Trafford tiles (reinforced asbestos) of 3 lb. per square foot weight, the same material being chosen for the lantern louvers. The weight of the Crittall glazing for the roof lantern and side walls was 6 lb. per sq. ft. The brickwork and glazing were carried round the corners of the building, thus forming a continuous cover for the internal steelwork. At one corner of the building the floor level was 8 ft. below ground. The respective portions of the side walls and gable end were reinforced by buttresses and an air-raid shelter was provided adjacent to the side wall, covered by shrubs and flower beds.

Structural Design.—In designing the structure various matters had to be investigated, including structural considerations, questions of material, workmanship, welding procedure, erection and appearance. The basis of calculation was the same as that used for the comparison of the two designs as described above. Permissible working stresses were specified as follows :

Steelwork, except portals	9	tons per sq. in.
Portals, excluding wind	8	,, ,,
Portals, including wind	10	,, ,,

Calculations were generally based on the London County Council By-laws, and the calculations for the welds on the London County Council Welding Regulations, both of which came into force on January 1, 1938.

The general arrangement for the building and individual structural parts are shown in Figs. 7 to 12, on Plate XX. Instead of using simply supported purlins over a 20-ft. span, or continuous purlins, the arrangement with hinges and cantilevers was found to be more economical. The simple type of hinge is illustrated in Figs. 13 and 14, Plate XX.

Table III.

$$H = \frac{\int \frac{M_O M_H}{E I} ds}{\int \frac{M_H^2}{E I} ds} = \frac{\int \frac{M_O M_H I_C}{I} ds}{\int \frac{M_H^2 I_C}{I} ds} = \frac{\delta_{HO}}{\delta_{HH}}$$

- E = Young's modulus (constant).
- I = Moment of inertia.
- I_C = a constant moment of inertia adopted to simplify the calculation.
- s = Length of member measured along its axis.
- M_O = B.M. for the assumed simply-supported beam due to external loads.
- M_H = B.M. for the assumed simply-supported beam due to a reaction $H = -1$ directed outwards.
- δ_{HO} = Elastic movement of the support of the assumed simply-supported beam in direction of $H = -1$ due to external loads.
- δ_{HH} = Elastic movement of the support of the assumed simply-supported beam in direction of $H = -1$ due to $H = -1$.

Hinges were arranged in every second bay, thus facilitating erection. Purlins Nos. 1 and 5, on the right in Fig. 9, were 7 in. by 4 in. by 16 lb. I sections, all others were 6 in. by 3 in. by 12 lb. The lantern frames were calculated as two-pin frames of 16-ft. span, consisting of 6 in. by 4½ in. by 20 lb. I sections. The horizontal rails in the side walls and gable ends are exposed to vertical loads from the roof, brickwork and glazing, and to horizontal loads from the wind. One of the side rails forms the outer chord for the gantry bracing. The side rails are calculated as simply-supported beams over a 20-ft. span.

The horizontal gable-end wind girders, of 80 ft. 3 in. span, were designed for transmitting wind loads from the gable ends into the brake portals and foundations. These plate girders, of about 4 ft. overall depth with horizontal web, made it possible to reduce considerably the sizes of the vertical stanchions at the gable ends. Access to the gable ends and crane tracks for inspection and maintenance is facilitated. Also, these substantial plate girders, together with the crane gantry and gantry bracing, form a continuous horizontal frame over the whole length and width of the building 30 ft. above floor level, thus considerably increasing its rigidity.

The crane-gantry girders were calculated as continuous beams. Bending moment, shear and reaction were determined by influence lines, two of which are reproduced in Fig. 34, on this page. The bending moments established by the influence lines were used for the calculation of welded joints only. At 6 ft. from the support :—

max. $M = 26 \times 20\ (0{\cdot}1373 + 0{\cdot}0810 - 0{\cdot}0510 - 0{\cdot}008 = +82{\cdot}8$ tons-ft.

min. $M = -26 \times 20\ (0{\cdot}0526 + 0{\cdot}0095 - 0{\cdot}0095) = -27{\cdot}3$ tons-ft.

At 4 ft. from the support :—

max. $M = 26 \times 20\ (0{\cdot}0987 + 0{\cdot}0170) = +60{\cdot}2$ tons-ft.

min. $M = -26 \times 20 \times 0{\cdot}0634 = -33{\cdot}0$ tons-ft.

The heaviest rolled-steel joist section available was used for the gantry girder, viz., 24 in. by 7½ in. by 95 lb., with a horizontal plate, 12 in. by ½ in., welded on top. Transverse horizontal loads are carried by a gantry bracing consisting of a continuous lattice girder. The top flange of the gantry girder, forming the inner chord of the gantry bracing, is subjected to axial compression or tension, but also to direct bending from horizontal wheel forces, acting laterally. Longitudinal horizontal loads due to braking and dragging are transmitted to the brake portals and foundations. The gantry bracing transmits its horizontal reactions to the main portals. As the lateral crane loads may act either inwards or outwards, all diagonals and posts of the gantry bracing had to be designed as struts. Notwithstanding their higher cost, tubular sections were found to be most convenient for this purpose. Tubes 3½ in. O.D. by No. 7 gauge were used.

The main portals are two-pin rigid frames of 80 ft. 3 in. span between centres of pins. The following loads had to be taken into account :

TABLE IV.—Forces, Bending Moments, and Stresses.

Section.	Axial Force.	Area.	Stress (0).	M_1.	Z.	Stress (1).	Stress (0) + (1).	Stress (1) (permissible).	M (permissible).	Section.
	Tons.	Sq. In.	Tons per Sq. In.	Tons-Ft.	In³.	Tons per Sq. In.			Tons-Ft.	
0	86·4	30·75	2·83	—	235	—	—	7·17	140	0
1	86·4	34·1	2·54	− 107·4	367	3·51	6·05	7·46	228	1
2	86·4	37·5	2·31	− 214·6	509	5·06	7·37	7·69	326	2
3	86·4	43·5	1·99	− 300·8	616	5·86	7·85	8·01	411	3
4	86·4	43·5	1·99	− 386·4	616	7·52	9·51	8·01	411	4
5	22·0	43·5	0·51	− 411·6	616	8·00	8·51	9·49	486	5
7	11·6	40·25	0·29	− 283·3	466	7·30	7·59	9·71	377·5	7
8	11·6	28·0	0·42	− 173·4	291	7·14	7·56	9·58	232·5	8
9	11·6	28·0	0·42	+ 159·0	291	6·56	6·98	9·58	232·5	9
10	11·6	28·0	0·42	+ 123·6	291	5·10	5·52	9·58	232·5	10
11	11·6	28·0	0·42	+ 86·7	291	3·68	4·10	9·58	232·5	11

Deadweight of portals, purlins and roof covering; weight of lantern; 30 lb. per square foot superimposed load on roof; wind on lantern and on side walls; and the vertical and horizontal loads from cranes. The horizontal thrust at pin level was calculated from the expression given in Table III, opposite. Values for the numerator and denominator were calculated for 11 cross sections over half of the frame, with seven types of loading, *a* to *g*, as indicated in the bending moment diagram given in Fig. 35. Unit loads were introduced to simplify calculations, the actual loads being used only for calculating final values. The resulting axial forces, bending moments and stresses are shown in Table IV, together with the areas and section moduli for cross sections 0 to 11. Axial stresses are marked (0), and bending stresses (1).

Bending moments due to various loads are shown in Fig. 35. The line indicating permissible bending moments has been calculated as follows:—Permissible bending stress = 10 tons per square inch minus stress due to axial compression; permissible bending moment = permissible bending stress multiplied by section modulus Z at the respective cross-section. It will be seen from Table IV and from the bending-moment diagram that at point 4 (at the bottom end of the crane gantry bracket) and between points 7 and 8, the calculated stresses come fairly near to the permissible figures. There is, however, an ample reserve provided by the severe assumption for live loads. The form and dimensions of the main portals can be seen from Figs. 15 to 26, Plate XX. In many respects the design of these rigid frames was influenced by considerations of workmanship, welding procedure and method of erection.

Most of the wind load on the gable end is carried by the gable-end wind girder, *i.e.*, 4-ft. deep plate girder described above. There remains, however, the wind load on the top portion of the gable end, which is transmitted into the wind bracing in both end bays of the roof. Light diagonals were introduced and purlins acting as posts were reinforced by welding a 5 in. by 2½ in. by 10·22 lb. channel to the 6 in. by 3 in. by 12 lb. joists. The top flanges of the rigid portal beam form the chords of the wind bracing. The horizontal reactions are taken by the wind portals which are provided in the end bays of the side walls. Their reactions are transmitted through the crane gantry into the brake portals and foundations.

The wind loads, however, are of secondary importance as compared with the longitudinal live loads produced by braking and dragging of the travelling cranes. All these horizontal longitudinal loads act parallel to and outside the plane of the brake portals. The eccentricity is about 2 ft. 7 in., producing additional bending moments and reactions in the main portals. The arrangement in plan of two pairs of the brake portals is shown in Fig. 27, on Plate XX. The dimensions of the portals, arrangement of stiffeners and main joints, which again were designed to facilitate erection, are shown in Figs. 28 to 33.

Calculation of Welds.—Calculation of the welded joints was based on the London County Council Regulations of December 7, 1937, which came into operation on January 1, 1938. Permissible stresses in welds were taken as follows:—

Tension and compression in butt welds	8	tons per sq. in.
Shear in butt welds in webs ...	6	,, ,,
Shear in butt welds other than webs	5	,, ,,
Stress in end fillets	6	,, ,,
Stress in side fillets	5	,, ,,

Fillet welds were made continuous throughout the main parts. They are mostly of ½-in. leg, with certain exceptions; for instance, for the gantry bracket, at the top end of which the full tension is transmitted by end fillet welds of ½-in. leg. For stiffeners, etc., continuous ⅜-in. fillet welds were used. Erection welding was restricted to a minimum and very little overhead welding had to be done. Wherever possible butt welds were used and designed to develop the full capacity of the member.

Foundations.—Foundation blocks for the main portals had to be designed for the following loads:—

Vertical load	90·6	tons
Horizontal, outwards	14·3	,,
Horizontal, inwards	8·8	,,
Permissible pressure on subsoil ...	2·25	tons per sq. ft.

The calculated maximum pressure was 2·16 tons per square foot. Uplift had to be taken into account. This is due to the continuity of the gantry girder (as can be seen from the influence lines for reaction at support), also to braking and dragging effects and to wind on the gable end. After deducting the minimum dead load, there still remains at the base plate an uplift of 17·0 tons, which had to be considered in designing certain welded joints, bolts and anchorages.

(To be continued.)

LITERATURE.

Boiler Operator's Guide. By HARRY M. SPRING, JUNR. London: McGraw-Hill Publishing Company, Limited. [Price 20*s.*]

THIS American book, dealing with the construction, operation, inspection, and maintenance of steam boilers, is more particularly intended for boiler inspectors and those who have to pass examinations of the type required of such officials in the United States. Over three hundred steam engineers' typical examination questions and answers are included. In spite of this rather specialised appeal, the book contains much of interest to British engineers, and is well written and thoroughly up to date. It includes, for example, descriptions of Dowtherm boilers, and of the use of diphenyl, diphenyloxide, and similar stable organic liquids for heat transmission; also of the Tomlinson water-tube boiler and furnace arrangement for the combustion of the organic residues left by the evaporation of waste liquors in the paper industry. The author describes concisely what he terms "special service" European boilers, that is, the Loeffler, La Mont, Velox, and Benson. He gives no indication, however, of the revolutionary pioneer work of Mark Benson on the forced-circulation mono-tube generator, and does not mention the Atmos, Ramzin, Schmidt-Hartman, and Sulzer generators.

There are some excellent chapters on American straight-tube natural-circulation water-tube boilers, including the Babcock and Wilcox, Heine, Keeler, Murray, Springfield, and Wickes types, and also on bent-tube boilers, such as the Combustion Engineering, the Riley, and the Stirling. One of the best chapters is that dealing with boiler appliances and auxiliaries, including safety valves, gauge glasses, blow-down valves, check valves, feed-water regulators and feed-water heaters, as well as economisers and feed pumps. The references to superheaters, de-superheaters, and water-cooled steel-tube combustion-chamber walls are concise and good, but pulverised-coal firing equipment, mechanical stokers and air heaters are treated less fully than their importance warrants. A considerable amount of space is naturally devoted to steam generation practice from the boiler inspector's viewpoint; internal and external corrosion are discussed, and there is much that is interesting on embrittlement and carry-over in steam. The author, as a boiler inspector himself, has some pungent comments to make about boiler compositions. There are some useful appendices, including a glossary of boiler terms.

Acoustics. By PERCY L. MARKS. London: The Technical Press, Limited. [Price 7*s.* 6*d.* net.]

THE title, *Acoustics*, which appears on the cover of this book is misleadingly comprehensive; even the qualifying sub-title, *A Handbook for Architects and Engineers*, conveys too ambitious an idea as to its scope. Actually, it is concerned solely with a single specialised branch of technical acoustics, which is treated in two parts and four appendices. Part I consists largely of extracts from works, mostly by recognised authorities, dealing directly or incidentally with architectural acoustics. It is well-nigh impossible to weld a succession of snippets, from sources dating from the First Century B.C. to the present day, into a coherent whole, even when the attempt is not marred, as this is, by indications that the author is insufficiently familiar with the fundamental physical principles involved. Thus, Sabine's reverberation formula is quoted (incorrectly) without any definition of the time of reverberation being given, and with the quantity *a* wrongly stated as "giving the absorbing power per square foot of the various materials . . ." More recent modifications of the reverberation formula are not even mentioned. Other expressions, such, for example, as "the velocity of sound through other media than air is mostly much more rapid, but in the case of iron it tallies very closely" are physically inexcusable. The author's curious attempt to differentiate between loudness and noise, on pages 30 and 31, does, indeed, leave him in some doubt whether his "definitions will be invariably approved." Moreover, where, in the absence of clear definition, confusion is possible, as in the distinction between the decibel and the phon, he merely succeeds in adding to it. Remarks such as "bad proportions induce reverberation as the reflecting angles are not regulated to control the passage of notes" (page 20) appear to be meaningless.

In Part II, Mr. Marks has summarised the trade literature issued in connection with the various brands of acoustic absorbents now available commercially. This body of useful information would be handier if the results had been tabulated in some such form as in the April, 1940, issue of the *Official Bulletin* of the Acoustical Materials Association (of America), and if the same convention regarding the frequencies at which the absorption coefficients were measured had been adopted throughout. Incidentally, absorption coefficients are not, as stated, measured in cycles per second.

The four appendices consist, respectively, of an extract from F. R. Watson's well-known *Acoustics of Buildings*; a note from the Department of Scientific and Industrial Research on the design of concrete floors to reduce the transmission of sound; a semi-political summary of a report on the construction of "working class" flats; and a less contentious account of the acoustic treatment of flats to let at "middle rent" rentals. Enough study along strictly scientific lines has now been carried out to make faulty acoustics as reprehensible a defect in a building as inefficient lighting or bad ventilation; but, if architects and engineers are to tackle their acoustical problems along any but the crudest of rule-of-thumb lines, they will need a better understanding of the basic principles of acoustics than is to be obtained from the present work.

Symmetrical Component Analysis of Unsymmetrical Polyphase Systems. By R. DIPL. ING. NEUMANN. London: Sir Isaac Pitman and Sons, Limited. [Price 21*s.* net.]

A SIMPLE and extreme case of the analysis of an unsymmetrical system into two symmetrical three-phase systems has been familiar to electrical engineers for many years and was first pointed out by Ferraris, who showed, at the close of the century, that an alternating magnetic field could be resolved into two rotating fields of constant and equal magnitude, rotating in opposite directions. This method was found to be of great service in the early days of alternating-current machinery for the investigation, for example, of the single-phase induction motor when that machine was much more widely used than it is to-day. It also provided a very helpful means for studying the effects of armature reaction in the case of single-phase alternators, and for a two-phase short-circuit condition of a three-phase generator. Mr. Neumann's book gives a comprehensive treatment of the generalised form of the principle of symmetrical component analysis. This analysis has become of immense importance in recent years for the investigation of the vast number of special problems which have arisen during the amazingly rapid growth of the inter-connected electric-power systems which are now in operation in all parts of the world. The development of this principle in the generalised form, including the zero component as well as the positive and negative phase sequence components, has been largely due to the late C. L. Fortescue, of the United States, whose paper in the *Transactions* of the American Institute of Electrical Engineers, in 1918, provided the foundation for most of the applications which have since been made.

The first three chapters of this book deal with a series of geometrical and analytical principles which are necessary for a clear understanding of the discussion of the analysis of unsymmetrical poly-

phase systems, and these are followed by the development of methods for the measurement of the positive and negative phase sequence components and the zero component, respectively. The fourth chapter deals with the applications of the analysis to a wide range of practical problems, such as line faults, the effects of unsymmetry of the supply pressure on the performance of three-phase induction motors, the phase converter of Kando as used for the Hungarian State Railways, the Scott transformer system, relays, the Petersen coil protective systems, and measuring instruments. There is a bibliography of 280 author references and a very complete general index. Although the book consists of only 219 pages, it is, perhaps, the most comprehensive treatment of the subject which has yet appeared; indeed, it induces a feeling that too much material has been compressed into too small a space. The usefulness of this valuable treatise would have been enhanced if representative practical problems had been more freely considered as immediate examples of the applications of the principles discussed in the earlier parts of the book. A further helpful modification would have been to compare and contrast solutions of certain problems as obtained by ordinary vector methods and by the method of symmetrical component analysis. This, no doubt, would have involved a considerable increase in the size of the book and a more selective distribution of the material. It is not always easy for an author who has become immersed in a highly specialised subject to appreciate the assistance that would be given in promoting the wider knowledge of a powerful, and in some respects, a novel tool among readers who are not so familiar with it. if frequent interludes were provided in which the virtues of the method were surveyed and emphasised by means of carefully selected practical examples.

Applied Chemistry for Engineers. By Dr. Eric S. Gyngell. London: Edward Arnold and Company. [Price 15*s.* net.]

Mr. Gyngell, in his preface, states that he has dealt with "the chemistry of materials and processes used by the engineer," which, if taken literally, would cover the whole field of applied chemistry and chemical engineering. Obviously, therefore, with a book of this type much available material of importance has to be omitted; but it is surprising to find that this includes metallurgy, passed over because the subject is recognised to demand a book in itself. The chemistry of metals, and metallurgy generally, might have been thought to be about the last subject that would be sacrificed in a book dealing with applied chemistry for engineers; certainly, if it is possible to deal with petroleum technology, synthetic liquid fuels, hydrogenation, oil-shale carbonisation, coke-oven practice, and low-temperature carbonisation, for example, all represented by a vast literature, in less than two pages each, some space might have been found for metallurgy. Incidentally, the entire subject of mechanical stoking for Lancashire and other cylindrical boilers is dismissed in exactly three lines, although two illustrations are included of a "Hotchkinson" stoker, evidently a mistake for Hodgkinson. It is equally surprising that no details are given of any methods of analysis or testing—because, it is stated, "full working instructions" are readily obtainable. The further observation, that the combustion of gas is not usually attended with any serious difficulties, suggests that the author is not familiar with the subject of turbulent burners, and the hundreds of patents associated with it.

The book is divided into six sections, which deal briefly with fuels and combustion, metallic corrosion, paints and varnishes, water treatment and sewage disposal, cements, and lubrication. In the first section, reference is made to the composition and formation of wood, peat, lignite and coal; to the coal-carbonisation industries, including both town gas and metallurgical coke; producer gas, the petroleum industry, the combustion of liquid fuels, and the science of combustion. The chapters dealing with corrosion form the best section of the book. Those on water softening are fairly adequate; but, in general, the work hardly lives up to the comprehensive promise of its title.

THE BUCKLING OF A THIN CIRCULAR ARCH.*

By Professor Dr. Julius Ratzersdorfer.

Let us consider a curved bar with its centre line in the form of an arc of a circle of radius r and a constant thickness which is small in comparison with the other dimensions. The arc is submitted to the action of a uniformly distributed pressure p per unit of length. It is in equilibrium with a uniform compression by the forces $P = p\,r$ in the direction of the tangent to the arc. If p exceeds a certain value, however, the bar bends, and, besides the longitudinal compression, a flexure is also caused. We now consider the case of bending of the axis in its plane in relation to the important hypothesis that the direction of the pressure p remains unchanged during the deformation.

Elastic Equations and Conditions for Equilibrium.—A point m on the centre line defined by the angle ϕ, Fig. 1, attains during bending the position m^1 with the radial displacement w and the tangential displacement v. Under a deformation without change of length with the condition

$$w = \frac{dv}{d\phi}$$

the elastic equations are given by the following terms.† The bending moment M in the bar is

$$M = \frac{EI}{r^2}\left(\frac{dv}{d\phi} + \frac{d^2v}{d\phi^2}\right),$$

in which E I is the flexural rigidity of the bar in the plane of its initial curvature. The radius of curvature ρ of the deformed axis is represented by

$$\frac{1}{\rho} = \frac{1}{r} + \frac{1}{r^2}\left(\frac{dv}{d\phi} + \frac{d^2v}{d\phi^2}\right).$$

The rotation of the tangent on the arc denoted by the angle ψ has the value

$$\psi = \frac{v}{r} + \frac{1}{r}\frac{d^2v}{d\phi^2}.$$

Fig. 2 shows the point m and its position m^1 after the deformation. The angle in the centre of the arc, $m\,o\,m^1$, is $\frac{v}{r}$, and the angle between $o\,m^1$ and the new tangent of the arc is given by $\frac{\pi}{2} - \left(\frac{v}{r} - \psi\right)$. With the displacements v, w the compression P is increased by forces and moments of infinitesimal quantity; these are the tangential force T, the normal force N, and the bending moment M in the plane of the bar. Consider an element of the axis of unit length and set down the conditions of equilibrium for forces in the axes x, y and for moments (see Figs. 2 and 3). Neglecting small quantities of higher than first order and taking for small angles the cosine equal to unity and the sine equal to the angle, we obtain the equations

$$\frac{dN}{ds} + p - (P + T)\frac{1}{\rho} = 0, \quad . \quad . \quad (1)$$

$$\frac{dT}{ds} + N\frac{1}{\rho} - p\psi = 0, \quad . \quad . \quad (2)$$

$$\frac{dM}{ds} + N = 0 \quad . \quad . \quad (3)$$

Fig. 1.

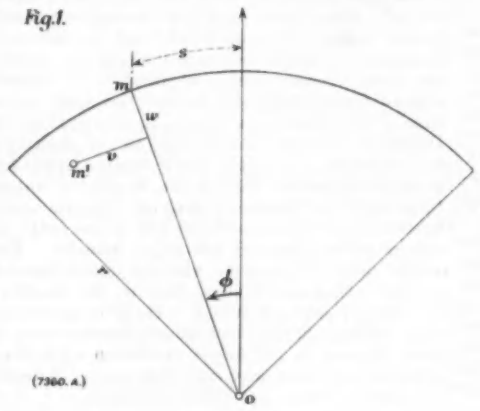


Fig. 2.

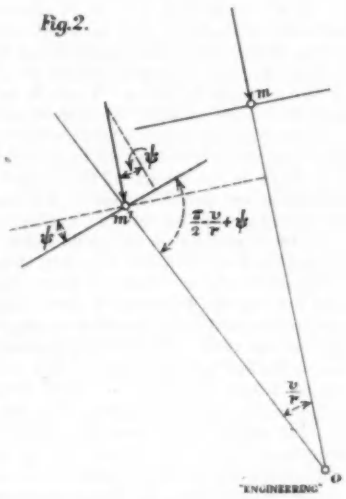
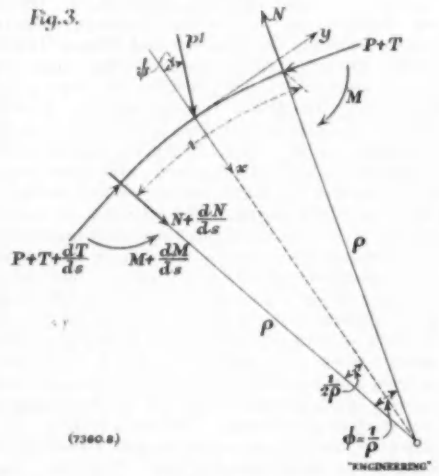


Fig. 3.



By differentiation of (1) and writing $\frac{1}{\rho} = K$, and $P = p\,r$, we obtain

$$\frac{d^2N}{ds^2} - (pr + T)\frac{dK}{ds} - K\frac{dT}{ds} = 0 \quad . \quad (4)$$

Substituting the values from (1), (2) and (3)

$$pr + T = \frac{1}{K}\left(p + \frac{dN}{ds}\right), \quad \frac{dT}{ds} = -KN + p\left(\frac{v}{r} + r\frac{d^2v}{ds^2}\right),$$

$$N = -\frac{dM}{ds} = -EI\frac{dK}{ds}$$

in the relation (4), we obtain the differential equation

$$\frac{d^3K}{ds^3} + \frac{dK}{ds}\left(K^2 + \frac{p}{EIK}\right) + \frac{K}{EI}p\left(\frac{v}{r} + r\frac{d^2v}{ds^2}\right) = \frac{1}{K}\frac{dK}{ds}\frac{d^2K}{ds^2}.$$

Putting for K the term $\frac{1}{r} + \frac{1}{r}\frac{dv}{ds} + r\frac{d^2v}{ds^2}$ and neglecting terms of higher than first order, we have the result

$$\frac{d^6v}{ds^6} + \frac{1}{r^2}\left(2 + \frac{pr^3}{EI}\right)\frac{d^4v}{ds^4} + \frac{1}{r^4}\left(1 + \frac{2pr^3}{EI}\right)\frac{d^2v}{ds^2} + \frac{pr^3}{EI}\frac{v^6}{r^6} = 0.$$

Using the notation $\frac{pr^3}{EI} = z^2$, the general solution of this equation becomes

$$v = C_1 \cdot \sin\frac{s}{r} + C_2 \cdot \frac{s}{r} \cdot \cos\frac{s}{r} + C_3 \cdot \sin\frac{sz}{r} + C_4 \cdot \cos\frac{s}{r} + C_5 \cdot \frac{s}{r} \cdot \sin\frac{s}{r} + C_6 \cdot \cos\frac{sz}{r}.$$

The six constants of integration C will now be determined from the boundary conditions of the problem. Equating the determinant of these homogeneous linear equations to zero, we get the buckling condition, or the relations for the critical value of the pressure.

Circular Arch with Hinged Ends.—At the ends of the bar, the displacements and the bending

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* See the writer's paper, "Ueber die Stabilität des Kreisringes in seiner Ebene," *Zeitschr. Oesterr. Ing.-u. Arch. Verein*, vol. 90, page 146 (1938).

† See author's book, *Die Knickfestigkeit von Stäben und Stabwerken*, Vienna, 1936, page 306.

moments are zero. With the length of the circular centre line $s = 2b$ and the origin of the co-ordinate axes in the middle of the bar, the boundary conditions have the form

$$s = \pm b,\ v = 0,\ w = \frac{dv}{d\phi} = 0,\ M \equiv \frac{d^2v}{d\phi^2} = 0.$$

Substituting here the expressions for v, we obtain, with the abbreviation $b : r = \alpha$, the equations

$$0 = C_1 . \sin\alpha + C_2 . \alpha . \cos\alpha + C_3 . \sin z\alpha + C_4 . \cos\alpha + C_5 . \alpha . \sin\alpha + C_6 . \cos z\alpha,$$

$$0 = -C_1 . \sin\alpha - C_2 . \alpha . \cos\alpha - C_3 . \sin z\alpha + C_4 . \cos\alpha + C_5 . \alpha . \sin\alpha + C_6 . \cos z\alpha,$$

$$0 = C_1 . \cos\alpha + C_2 (\cos\alpha - \alpha . \sin\alpha) + C_3 . z . \cos z\alpha - C_4 . \sin\alpha + C_5 (\sin\alpha + \alpha . \cos\alpha) - C_6 . z . \sin z\alpha,$$

$$0 = C_1 . \cos\alpha + C_2 (\cos\alpha - \alpha . \sin\alpha) + C_3 . z . \cos z\alpha + C_4 . \sin\alpha - C_5 (\sin\alpha + \alpha . \cos\alpha) + C_6 . z . \sin z\alpha,$$

$$0 = -C_1 . \cos\alpha + C_2 (\alpha . \sin\alpha - 3\cos\alpha) - C_3 . z^2 . \cos z\alpha + C_4 . \sin\alpha - C_5 (\alpha . \cos\alpha + 3\sin\alpha) + C_6 . z^2 . \sin z\alpha,$$

$$0 = -C_1 . \cos\alpha + C_2 (\alpha . \sin\alpha - 3\cos\alpha) - C_3 . z^2 . \cos z\alpha - C_4 . \sin\alpha + C_5 (\alpha . \cos\alpha + 3\sin\alpha) - C_6 . z^2 . \sin z\alpha.$$

Adding or substracting the corresponding relations, we get two groups of three equations each with three constants.

$$0 = C_1 . \sin\alpha + C_2 . \alpha . \cos\alpha + C_3 . \sin z\alpha,$$

$$0 = C_1 . \cos\alpha + C_2 (\cos\alpha - \alpha . \sin\alpha) + C_3 . z . \cos z\alpha,$$

$$0 = C_1 . \cos\alpha - C_2 (\alpha . \sin\alpha - 3\cos\alpha) + C_3 . z^2 . \cos z\alpha.$$

$$0 = C_4 . \cos\alpha + C_5 . \alpha . \sin\alpha + C_6 . \cos z\alpha,$$

$$0 = C_4 . \sin\alpha - C_5 (\sin\alpha + \alpha . \cos\alpha) + C_6 . z . \sin z\alpha,$$

$$0 = C_4 . \sin\alpha - C_5 (\alpha\cos\alpha + 3\sin\alpha) + C_6 . z^2 . \sin z\alpha.$$

The buckling condition will reduce to that of two determinants and we have

$$z(z^2 - 3)\sin 2\alpha + 2z(z^2 - 1)\alpha + 4\ \text{cotan}\ z\alpha . \sin^2\alpha = 0 \quad . \quad . \quad (5)$$

$$z(z^2 - 3)\sin 2\alpha - 2z(z^2 - 1)\alpha + 4\tan z\alpha . \cos^2\alpha = 0 \quad . \quad . \quad (6)$$

In the series of coefficients z we now determine the least value of z above unity, and from this the critical pressure p_K is given. The root $z = 1$ leads to $M = 0$, *i.e.*, to equilibrium without flexure.

The calculated critical pressure p_K for various values of α is shown in the following table :—

$\alpha = \frac{b}{r} =$	30 deg.	60 deg.	90 deg.	120 deg.	150 deg.	180 deg.
$p_K \frac{r^3}{EI} =$	35·94	8.73	3·27	5·01	3·02	1·72

The solution for the first three angles is determined by equation (6), and for the last by (5).

Circular Arch with Built-in Ends.—The displacements and the angles of rotation of the ends are equal to zero and with the length of the arch $2b$ we have the boundary conditions

$$s = \pm b,\ v = 0,\ w = \frac{dv}{d\phi} = 0,\ \psi \equiv \frac{d^2v}{d\phi^2} = 0.$$

A calculation carried out in the same manner as in the preceding case gives the two buckling conditions

$$(z^2 + 1)\sin 2\alpha + 2(z^2 - 1)\alpha - 4z . \tan z\alpha . \cos^2\alpha = 0 \quad . \quad . \quad (7)$$

$$(z^2 + 1)\sin 2\alpha - 2(z^2 - 1)\alpha - 4z . \cot z\alpha . \sin^2\alpha = 0 \quad . \quad . \quad (8)$$

Several solutions for the critical uniform pressure p_K are obtained in the following table :—

$\alpha = \frac{b}{r} =$	30 deg.	60 deg.	90 deg.	120 deg.	150 deg.	180 deg.
$p_K \frac{r^3}{EI} =$	74·95	19·59	9·0	4·63	1·99	4·0

The values p_K are found for $\alpha = \pi$ of equation (8), for the other angles of (7).

Complete Circular Ring.—In the case of a circular ring, the displacement v must be a periodic function of $\frac{s}{r}$ with the period 2π. In the expression for v we must eliminate the constants C_2 and C_5 and z gives the values 0, 1, 2, etc. The root $z = 0$ is $p = 0$, but $z = 1$ is also a deformation without flexure, because the bending moment M becomes zero. The critical pressure is given by $z = 2$ by the formula

$$p_K = \frac{4\,EI}{r^3},$$

in accordance with the result for the arch with both ends built-in, by $\alpha = \pi$.

It is interesting to note that we obtain this solution starting from a regular polygonal ring on the hypothesis that the direction of the external forces remains unchanged during the deformation without a change of length.* For a regular polygon with the total length L and n equal and equally compressed sides, the critical force in the bars is determined for $n = 3$ by

$$P_K = 13{\cdot}6\,\frac{\pi^2 EI}{L^2},$$

and for $n > 3$ by

$$P_K = 16\,\frac{\pi^2 EI}{L^2}.$$

For a circular ring with $L = 2\pi r$, and $P_K = p_K . r$, we now obtain

$$p_K = 4\,\frac{EI}{r^3},$$

an expression in accurate agreement with the above result.

The well-known formula of M. Levy, $p_K = 3\,\frac{EI}{r^3}$ is given for a hydrostatic pressure which is always normal to the direction of the deformed axis, and the result of E. L. Nicolai $p_K = 4,5\,\frac{EI}{r^3}$ leads to the hypothesis that the uniformly distributed external forces act always towards the centre of the arch.

MEASUREMENT OF CYLINDER POWER OF HIGH-SPEED STEAM LOCOMOTIVES.*

By L. K. Botteron.

Steam locomotives now run for short periods at speeds in excess of 100 m.p.h. Speeds of 90 m.p.h. for sustained periods are not unusual. Running over a division at 75 m.p.h., with the exception of the acceleration and deceleration periods in stopping, starting, and observing local speed restrictions, is common practice. At diameter speed, that is, a speed in miles per hour equal to the diameter of the driving wheel in inches, the driving wheel rotates at 336 r.p.m.; high-speed passenger locomotives operate a considerable part of the time at higher than diameter speeds. Considering the size of locomotive cylinders, the rotational speeds are high as compared with other reciprocating engines. The difficulties encountered in taking indicator cards on high-speed steam locomotives are many and it must be borne in mind that, compared with the indicating of stationary engines, the problems encountered are far more complex. Reducing motions are a constant source of trouble due to breaking and rapid wear, as they must run unprotected from the weather. Due to roadway clearances and interferences of locomotive parts, it is often difficult to apply any sort of a reducing motion. Common to all indicators driven with a reducing motion, the stretching of the indicator cord increases as the speed increases, the indicator-drum spring is hard to adjust correctly, and even the drum is a source of errors due to its inertia. L. Pendred, in an article† on high-speed indicators, does not believe any reciprocating reducing motion is reliable above 500 r.p.m. In the case of steam locomotives, this limit, more likely, would be 300 r.p.m. Mechanical indicators of simple and rugged construction for speeds up to 500 r.p.m. are on the market but, if the indicator-drum motion does not proportionally follow the cross-head, the cards are of little or no value.

Since reducing motions, cord stretch, and drum inertia are such a source of error, the thought arises that it might be better to dispense with the reducing motion entirely and drive the drum at constant speed in one direction. In this case it would be necessary to apply an apparatus for marking crosshead dead centres on the card. Also, the drum speeds would have to be high: a locomotive with 80-in. diameter drivers, at a speed of 100 m.p.h., is making 420 r.p.m., which completes a cycle in ½ second. To obtain cards 3 in. long, paper travel of 1½ ft. per second would be required.

The errors common to the mechanical indicator are well covered in technical literature. On the steam locomotive, all of the mechanical-indicator errors and troubles common to stationary work are encountered, plus some additional ones. The most troublesome of these are the severe rapid vibrations of the front end of the locomotive at high speeds. Front-end vibration will, in turn, vibrate the entire indicator and especially disturb the pencil motion. Sticking pistons are common, due to highly superheated steam and bits of boiler scale and other foreign matter getting into the indicator cylinder. The operator labours under conditions which are not conducive to good work. There is also the possibility of the locomotive meeting with an accident, such as knocking out a cylinder head. Due to clearance limits, indicators usually cannot extend out beyond the width of the cylinders. This means that indicators cannot be connected directly into the cylinders. Instead, relatively long pipes must be used between the cylinder and the indicator, in order to locate the instrument so that it is accessible to the operator and within clearance limits. The errors due to long pipes are very serious and at high speeds the events, as shown by the card, lag so far behind the actual events in the cylinder as to make the card valueless both as for the events and the mean effective pressure.*

Mechanical indicators, developed primarily for internal-combustion engine testing, offer possibilities for high-speed steam-locomotive testing, provided the drum is driven at constant speed and not by a reducing motion. However, the errors due to long pipes and locomotive vibration would still be present, and the operator would have to ride at the front end. Pressure-time cards instead of pressure-volume cards would be obtained and, to determine the m.e.p., it would be necessary to redraw the cards on a pressure-volume basis unless a special integrator were available. Optical indicators do not seem to offer any possibilities for locomotive road tests. They are essentially laboratory instruments and are not rugged enough to stand shocks and vibrations.

The indicator which offers possibilities for determining the indicated horse-power of high-speed steam passenger locomotives is the electrical type, such as the Martin and Caris indicator,† the indicator described by H. T. Sawyer,‡ and that of the General Electric Company.§ With the electrical indicator, the only apparatus required on the locomotive are the pressure-measuring heads, an electric dead-centre marker, and wiring running back to the test car. The oscillograph, which is the recording instrument, would be carried on the test car. The electrical indicator therefore possesses many inherent advantages over other types. The pressure-measuring heads are attached directly to each head of each cylinder, thereby eliminating the error due to piping. Any number of cylinders can be indicated simultaneously. Reducing motion is not used. The operator is not required to ride at the front end. Conditions which might interfere with the accuracy of the electrical indicator are the effects of vibration and temperature differences on the pressure-measuring heads. The electrical indicator makes only pressure-time cards, but with a special integrator the m.e.p. of such cards may be directly determined.

Due to the limitations of mechanical indicators and the hazard of men riding at the front end, the research and mechanical-standards department of the Union Pacific Railroad Company has used the heat-drop method for determining the steam rates and indicated horse-power of high-speed steam passenger locomotives. The methods of Arthur Williams‖ have been followed and the results obtained for high-speed work have been found to be reasonably accurate. Briefly, the heat-drop method is based on the first law of thermodynamics. Thus, in the case of the steam locomotive, the difference between the total heat in the steam to the cylinders and the steam exhausted from the cylinders is converted into mechanical work regardless of the processes which go on in the cylinder. The question has been raised as to the proper location of thermocouples for measuring exhaust-steam temperatures and it has been pointed out that the state of the steam during the exhaust period is variable.¶ The most reasonable location for the exhaust-steam thermocouples is in the exhaust-

* Paper presented at the semi-annual meeting of the American Society of Mechanical Engineers at Milwaukee, Wisconsin, June 17 to 20, 1940. Abridged.

† *The Engineer*, vol. 115, page 119 (1939).

* "The Effect Upon the Diagram of Long Pipe Connections for Steam-Engine Indicators," by W. F. M. Goss. *Trans. A.S.M.E.*, vol. 17, page 398 (1896).

† "A New Electrical Engine Indicator," by E. J. Martin and D. F. Caris. *S.A.E. Journal*, vol. 23, page 87 (1928)

‡ "An Indicator for High-Speed Engines," by H. T. Sawyer. *Mechanical Engineering*, vol. 58, page 283 (1936).

§ "To Measure Pressure Electrically," *Mechanical Engineering*, advt. page 7, November, 1939.

‖ "Measurement of Steam Rate and Indicated Horse-Power of Locomotives," by Arthur Williams. *Trans. A.S.M.E.*, vol. 57, page 495 (1935).

¶ *Ibid.*, discussion. *Trans. A.S.M.E.*, vol. 58, page 250 (1936).

nozzle stand, since the exhaust pressure at that point has the least pulsation and the steam has had time to mix. The heat content of the exhaust steam cannot change between the valve chamber and the exhaust stand, except for the influence of radiation and kinetic energy. If these two items are corrected for and the pressure and the temperature of the exhaust steam are accurately determined in the exhaust stand, it seems that a reasonably accurate determination might be made of the total energy.

The heat-drop method determines the steam rate only. In order to calculate the indicated horse-power it is necessary to know the steam to the engine as well as the steam rate. Knowing the pressure and temperature of the steam in the exhaust-nozzle stand, it is a simple matter to calculate the flow through the nozzle, provided the coefficient of discharge is known. Of course, all formulæ for steam flow are based upon steady conditions and some doubt will arise as to whether the formulæ hold true for locomotive conditions where the flow is pulsating. For low speeds, the pulsations are of such magnitude that the flow computed from the back pressure will be high. However, at high speeds, the exhausts are so frequent and the pressure fluctuations of such small magnitude that the gauge will read an average pressure, accurate enough for calculating the flow.

The exhaust-pressure gauge should be piped up so as to have a constant hydrostatic head. This can be done by running a pipe vertically from the side of the nozzle stand through the smokebox and terminating the pipe within the clearance limits. At this point, a coil of copper pipe is connected into the vertical pipe and a pipe with a gradual drop is run from the coil to the gauge in the cab. The vertical pipe should be 1 in. or larger to be self-draining. Either a mercury manometer or a suitable Bourdon-tube gauge may be used for indicating exhaust pressure in the cab.

A potentiometer will be found to work very satisfactorily for the determination of the temperatures, if the galvanometer is removed from the instrument and attached to the data board which is held by the operator when taking readings. Arthur Williams, in his paper,* illustrates and discusses such a mounting. During a test it is imperative to remove all auxiliary exhausts from the exhaust passages, as the exhaust steam from the auxiliaries is in a different state from the exhaust steam from the engines. Of course, the exhaust-steam temperature taken in the exhaust stand must be the temperature of the exhaust steam from the engine only. Also, by removing the auxiliary exhausts from the exhaust passages, the steam to the engines equals the steam through the nozzle in the case of locomotives equipped with live-steam injectors, while, in the case of locomotives equipped with feed-water heaters, the steam to the engines equals the steam through the nozzle plus the steam condensed from the exhaust passages for feed-water heating.

No definite data can be given which will cover the coefficients of discharge of locomotive-exhaust nozzles, due to such a wide variety of nozzles being used. Each railroad would have to determine the characteristics of its own nozzle. In general, it will be found that, for steady conditions, round-hole nozzles without sharp edges or projections and having a smooth approach in the stand, have coefficients of about 0·97 or 0·98 for their entire pressure range, while nozzles with complicated shapes and sharp edges have coefficients of 0·8 and lower at low back pressures, with the coefficient increasing up to a maximum of about 0·93 at 12 lb. per square inch pressure. The author calculated the flow through the plain round-hole exhaust nozzle of Baldwin locomotive No. 60,000, considering the flow adiabatic and using a coefficient of discharge of unity, but making no allowance for the velocity of the steam in the exhaust pipe.† The calculated results, compared with the test-plant measurements, show that, for exhaust-pipe pressures from 9·1 to 19·8 lb. per square inch, calculated flows are from 3·59 per cent. too high to 3·42 per cent. too low, with an average of 0·62 per cent. too low.

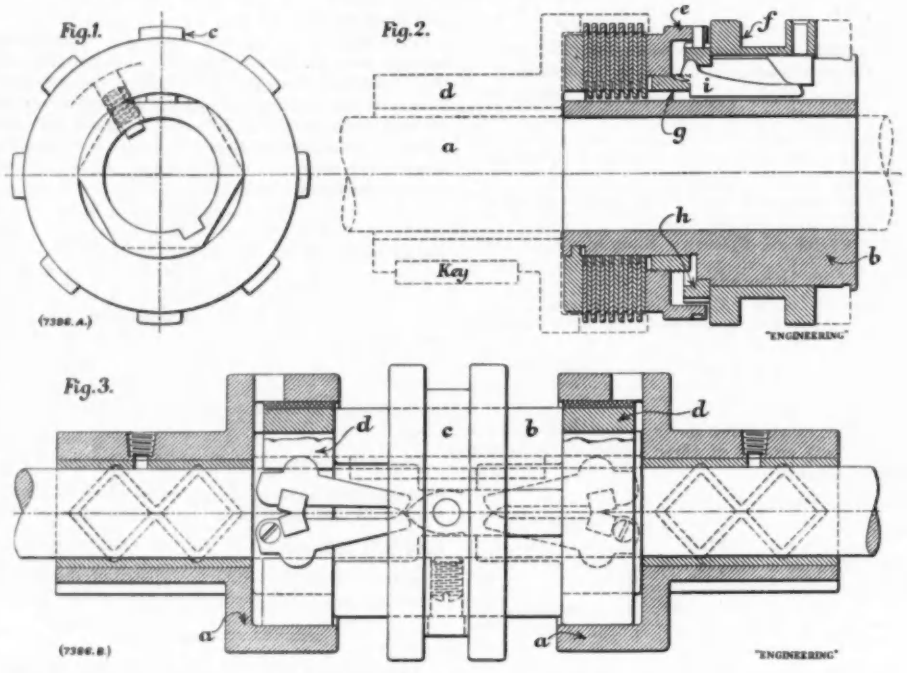
The equipment and procedures required for the use of the heat-drop method are simple. It is only necessary to measure steam-pipe and exhaust-stand pressures and temperatures accurately. The indicating potentiometer is a simple rugged instrument. If any wiring becomes broken, disconnected, or earthed, the potentiometer galvanometer cannot be balanced. Thus there is no possibility of false readings. Only one operator is required, and, by placing the potentiometer and pressure gauges in the cab, the operator is removed from the front end to a safer location. The heat-drop method has the advantage over all other methods that it determines both instantaneous steam rate and indicated horse-power. A set of readings can be worked up in about 20 minutes.

* *loc. cit.*

† "Locomotive Back Pressure," by L. K. Botteron, *Railway Mechanical Engineer*, vol. 104, page 400 (1930).

FRICTION CLUTCHES FOR LINE SHAFTING.

THE CARLYLE JOHNSON MACHINE COMPANY, MANCHESTER, CONN., U.S.A.



LINE-SHAFT FRICTION CLUTCHES.

The driving of machine tools and industrial machines, which have to be worked intermittently, by means of fast and loose pulleys and belts, is a practice of long standing in most countries. There appears, however, to be an increase in the United States in the alternative method of using one pulley only on the line shaft, this pulley being coupled and uncoupled, by means of a clutch, to the continuously-rotating shaft to start and stop the machine concerned. Two simple friction clutches for this purpose have been developed by Messrs. The Carlyle Johnson Machine Company, 52, Main-street, Manchester, Connecticut, U.S.A., and are shown in Figs. 1 to 3, above. The clutch illustrated in Figs. 1 and 2 is known as the "Maxitorq" single multi-disc clutch and, as this designation implies, is of the type in which the compression of a group of discs alternately mounted on the driving and driven elements sets up sufficient friction to these elements to engage. The driving shaft is indicated at *a* in Fig. 2, and the driving element of the clutch keyed to it is indicated at *b*. This element has, at the left, a flange against which the discs are compressed, there being seven of these discs threaded on a hexagonal part of the element to the right of the flange. Alternating with these discs are seven others, each formed with eight projecting lugs *c*, as shown in Fig. 1. The lugs enter slots in a cup-shaped part of the sleeve *d*, which is keyed to the boss of the driven pulley. The pulley, of course, is free on the shaft when the clutch is disengaged and the sleeve can be supplied with either a plain bronze bush having spiral oil-grooves, or with ball or other anti-friction bearings.

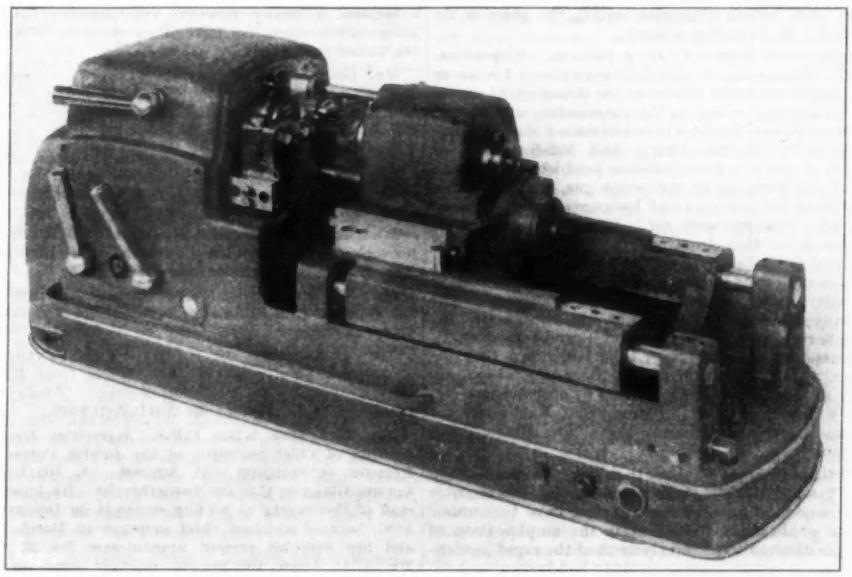
The driving element *b* is also provided with two sliding rings, viz., the disc-compression ring *e* and the actuating ring *f*, which takes the fork of the operating lever within reach of the machine attendant. The disc compression ring is in two parts, a smaller ring *g* being screwed into the larger ring *e*. The driving element *b* is fitted with a ring *h* having an internal recess and external peripheral notches. Between rings *g* and *h* are three levers *i*. These are shaped so that they rock on a fulcrum lying in the recess of ring *h*, and the short arm lies against the end surface of the ring *g*. The long arm of each lever lies in a recess in the actuating ring *f*, which recess is furnished internally with a lug having a sloping face. The clutch is shown in engagement in Fig. 2, from which view it will be appreciated that, by throwing over the actuating ring *f* from the disengaged position, indicated by dotted lines at the right, the long arm of the lever had been forced radially inwards and its short arm then applies pressure to the disc-compression ring *e*. This pressure is relieved when the actuating ring *f* is traversed from left to right to the disengaging position, since the long arms of the levers *i* are no longer pressed inwards. The reaction on the actuating ring *f* during engagement is met by the grub screw seen to the left of Fig. 1. The degree of pressure can be adjusted to allow for wear of the discs, by rotating the disc-compression ring *e*, a movement which causes it to traverse axially by the action of the screw on the ring *g*. The periphery of ring *e* is knurled to enable adjustment to be made easily and the ring is locked into the desired position by a small spring plunger which engages with one of the notches in ring *h*. The position of this plunger is indicated in Fig. 2, being shown immediately above the fulcrum of lever *i*.

The clutch is at present manufactured in small sizes only, the largest being suitable for shafts between $1\frac{3}{4}$ in. and $1\frac{7}{8}$ in. in diameter. The capacity of this clutch is 3 h.p. at 100 r.p.m. It is also made in a double form, *i.e.*, with two sets of discs, one on each side of the actuating ring. In this form, one set of discs is employed to engage a pulley having an open belt, the other set engaging with a pulley having a crossed belt so that forward and reverse drives can be obtained from the line shaft. A neutral, or non-driving, condition is obtained by moving the actuating ring to a central position. Both the single and double multi-disc clutches are made either to run in a dry condition or to run in oil. In the first instance, the discs are alternately of steel and bronze, while, in the second, all the discs are of hardened steel.

The second type of friction clutch mentioned earlier is not so recent in principle as the multi-disc clutch, but an example of the latest design is shown in Fig. 3. This clutch has an internal expanding-ring friction surface and, like the multi-disc clutch, is made in both the single and double patterns; the latter pattern is illustrated in Fig. 3. The sleeves *a*, on the right and left, and having cup-shaped flanges, run loose on the driving shaft, as may be inferred from the helical oil grooves, and are keyed into the pulley bosses, the key-way being indicated at the bottom in each case. A central sleeve *b* carries the sliding actuating ring *c*. Lying within each cup of the sleeves *a* is the C-shaped expanding ring, expansion being caused by the forcing apart of a pair of levers, due to the action of a wedge on the actuating ring. The levers are in contact on their inner faces, the point of contact forming a fulcrum for both. One of the levers is furnished with an adjusting screw for the contact faces. The adjustment is made by a narrow screw-driver through the hole seen in the top flange of the cups. The expanding ring is faced with a moulded friction material which enables the clutch to be run dry. Clutches of this type are made in a full range of sizes. The largest will accommodate shafts with a maximum bore of $3\frac{1}{16}$ in. The capacity is indicated by the fact that the clutch will slip at a torque of 1,305 lb. ft. The actuating ring is intended to be operated by a forked lever from the machine being driven. When this lever has a ratio of 5 to 1, the force required to engage the clutch is 100 lb.

AUTOMATIC SCREW MACHINE.

MESSRS. UNIT MACHINERY COMPANY, ROCKFORD, ILL., U.S.A.



Normal conditions, however, usually make a longer lever more convenient and, with the consequent increase in ratio, there is a decrease in the effort required. It will be obvious from the construction of the clutch that little modification in design is required to make it suitable for use as a disconnecting coupling for two shafts in line. It is used in this way for such applications as small marine engines, motors with direct drive or drive to gearboxes, and so forth.

AUTOMATIC SCREW MACHINE.

THE small machine shown in the accompanying illustration is intended for the formation of small parts from wire stock, operations which, in addition to screwing, may involve turning, drilling and parting. The name given to the machine by its manufacturers, Messrs. Unit Machinery Company, Rockford, Illinois, U.S.A., is the "Polymatic Former," the latter term being, perhaps, sufficiently descriptive. The two sizes in which the machine is made will deal with stock having maximum diameters of $\frac{5}{16}$ in. and $\frac{7}{16}$ in., respectively, the parts turned out in quantity being such as are used in electrical and other instruments, sewing machines, cash registers and similar light mechanisms. As regards length of work, turning can be done on pieces up to $\frac{1}{2}$ in. long in the smaller machine and up to 1 in. long in the larger machine, the maximum feed movement being $\frac{1}{2}$ in. and 2 in., respectively. The machine may be used either on the bench or on a base casting, the stock tube being arranged accordingly. This tube is fitted behind the headstock which is seen to the left in the figure, and is normally supplied to handle rods up to 12 ft. in length. A silencing device is provided, as the machine runs at a high speed.

The machine is provided with two cross slides and a tool slide. The former may be identified in front of the headstock, one on each side of the spindle. They are of hardened and ground steel, sliding on fine-grained cast-iron ways. A fully adjustable tool holder is fitted to each. The tool slide may be distinguished by the circular steel ways on which it is traversed, but, otherwise, the arrangement is not easy to follow from the illustration at first sight. Normally, the slide may be fitted with a compound saddle carrying one to three end-operating tools, with which such operations as drilling, reaming, turning and knurling may be carried out. The machine in the figure, however, is shown equipped with the optional attachment of a pick-up spindle. This spindle is mounted in a tailstock on the slide and is geared to the main spindle so that both rotate in precise synchronism. The pick-up spindle is hollow and is furnished with a collet which grips the work while it is being parted by one or other of the cross slides. This support prevents the premature breaking off of the work, which would result in a burr being formed. On completion of the parting operation, the collet opens and the part is pushed through the pick-up spindle to fall out at the back of the tailstock, clear of the swarf.

The main spindle is of heat-treated alloy steel. It is carried at the front in double-row roller bearings, the inner race of which is seated on a tapered part of the spindle, thus providing ready adjustment. The rear end of the spindle is carried on two radial thrust-type ball bearings. The final drive is by means of alloy-steel helical gears, hardened and lapped. The spindle contains a normal push-out type collet with feed finger and feed tube. The stock-feed movement is obtained from a closed harmonic cam which gives very accurate length measurement. The swinging stop may be seen on the overarm between the headstock and tailstock. The cross-slide movements are derived from individual plate cams. All the feed movements are controlled from a common shaft, the speed of which can be varied, by means of pick-off gears, from one revolution in 0·75 sec. to one in 24 sec. in the largest machine. As one cam cycle finishes one work piece, these rates are a measure of the output of the machine, which varies according to the particular operations involved.

The main spindle of the larger machine has a speed of from 2,200 r.p.m. to 10,000 r.p.m. in 30 changes. The power required is 2 h.p., the motor running at 1,800 r.p.m. and transmission to the final drive in the headstock being by Vee belts. Control is by means of a friction clutch, operated by a hand lever, for starting the spindle rotation and the feed movements. A second lever-operated clutch selects either power feed or hand feed. In the latter position, the operator can revolve the camshaft while the main spindle is running or is stopped. A third lever enables the spindle collet to be opened manually. Lubrication of all the moving parts in the headstock, etc., is effected by a small pump which starts up before the drive clutch is engaged. The Polymatic Former is distributed in this country by Messrs. Broadway Engineering Company, Limited, Carlisle-road, Hendon, London, N.W.9.

TIMBER EXPORTS FROM BRITISH COLUMBIA.*

LUMBER production in British Columbia is being accelerated to meet increasing needs for military purposes and war industries in both Canada and Great Britain. A Canadian Lumber Control has completed its preliminary organisation for the co-ordination of the industry, and the shipping space available for direct shipments from British Columbia has so increased that the rail movement across Canada is being curtailed. Lumber scaled during the first six months of 1940 comprised 1,678 million board ft. against 1,563 million in the same period last year, 1,167 million in 1938, and 1,276 million in 1937. Great Britain is the world's largest market for softwoods and, ordinarily, in addition to large purchases within the Empire, drew heavily from the Scandinavian and Baltic countries, including the Soviet Union. With these sources closed, the Canadian industry has a unique opportunity to become the chief supplier of these products to Great Britain.

The shortage of shipping space proved the greatest obstacle to be overcome. This situation was partly met by moving the lumber by rail across Canada to Atlantic ports, for inclusion in the regular convoy system. Considerable quantities were moved in this manner but, as the necessity disappeared, direct water shipments are being resumed in increasing volume. The total quantity of British Columbia lumber inspected for dispatch to Great Britain during the first seven months of 1940 was 553 million ft., or more than 70 per cent. of the total movement to all destinations. War conditions have now closed most outlets in Continental Europe, but France absorbed nearly 5 million ft. before its capitulation. The entry of Italy into the war has caused the cessation of supplies destined to that country. No shipments to Germany, Holland or Belgium were reported in 1940; during the first seven months of 1939 these countries purchased more than 5½ million board ft. In Asia, the Sino-Japanese conflict has caused a heavy falling off in shipments of British Columbian lumber. Chinese purchases during the 1940 period declined to 5·7 million board ft., as compared with 32 million during the corresponding period last year, and Japanese fell from 5 million to 650,000 ft.

Lumber Inspected for Waterborne Shipment from British Columbia Mills.

(Thousands of feet—Board Measure.)

Destination.	January to July.	
	1940.	1939.
Great Britain	553,329	514,246
Africa	64,032	34,563
Australia	54,258	90,901
Egypt and Palestine	16,036	509
China	5,715	31,895
West Indies	5,320	6,642
France	4,938	295
South Sea Isles	2,991	7,809
New Zealand	1,797	4,280
Arabia	1,290	—
Italy	685	124
Japan	650	5,224
Gibraltar	351	—
India	136	3,079
South America—East Coast	315	2,167
South America—West Coast	14	3,349
Belgium	—	1,831
Central America	—	918
Panama Canal Zone	—	551
Germany	—	2,741
Holland	—	1,078
Manchukuo	—	524
Unclassified	364	312
Total Overseas	712,221	713,038
United States	38,666	69,609
Canada	4,219	17,691
Grand Total	755,106	800,338

Shipments to other parts of the world have been variously affected. Cargoes of British Columbian lumber destined to African ports increased by 30 million ft., while a corresponding reduction is reported in purchases by Australia. A decline of more than 50 per cent., or 2¼ million ft., occurred in the case of New Zealand. The shipments to countries in Central and South America fell to negligible proportions during the 1940 period, as compared with purchases in excess of 5 million ft. during the first seven months of 1939. United States markets absorbed only 39 million ft. during the first seven months of 1940, against 69 million ft. last year, and Canadian purchases were also substantially reduced. Improvement in the latter is anticipated as the result of increased momentum in industrial activity due to war orders and the requirements of the Government for military establishments of various kinds. In spite of these losses, the movement, on the whole, has been well maintained, inspections for shipment to July 31 totalling 755 million ft., as compared with 800 million ft. to the same date last year. The difference of 45 million ft., it is anticipated, will be largely offset by the increased movement looked for during the remainder of the year, and the 1940 total should approximate to the record of 1,409 million ft. achieved in 1939. Shipments by destination, according to inspection returns, are shown in the above Table for the first seven months of the current year, as compared with the same period in 1939.

* From the *Monthly Letter* of the Royal Bank of Canada, August, 1940. Abridged.

CHADWICK PUBLIC LECTURES.—In consequence of present conditions, it has been decided to postpone, for the time being, the Chadwick Public Lectures, which were to have been delivered this autumn. Due notice will be given when the lectures are to be resumed.

ELECTRICAL WATER-HEATING INSTALLATION AT POPLAR TOWN HALL.

A recent example of the employment of electricity for heating water is to be found at the Town Hall of the Metropolitan Borough of Poplar, where the water for the heating and air-conditioning systems is supplied by thermal-storage plant. The equipment, which was constructed by Messrs. The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, consists of two 650-kW electrode circulators, which are directly connected to the 6,600-volt three-phase mains. Each heater has its own automatic control cubicle and high-voltage solenoid-operated oil circuit-breaker. A main instrument panel is also provided. The installation is designed to give sufficient heat for a full day's requirements when energy is supplied during the off-peak period only. In order to provide the necessary storage there are two 15,000-gallon cylinders, which work between the temperature limits of 150 deg. and 240 deg. F.

The two electrode circulators are of the high-voltage vertical type. The load is adjusted by raising or lowering the electrode shields, the movements being effected by motors driving through reduction gearing. It is claimed that this method enables wide load regulation to be obtained with water the resistance of which varies in the ratio of 4·25 to 1, due to temperature rise. The motors operating the electrode shields are controlled by a number of automatic and safety devices, which ensure that the load is reduced to a low value before the main circuit is made or broken by the oil switch. Load regulation is automatic and is controlled by special load-regulating relays, which can be set to give constant loadings of 30 per cent., 45 per cent., 60 per cent., 85 per cent., or 100 per cent. of the full load of each boiler. The load can also be regulated by hand or by push-buttons, which are placed on the control cubicle.

The water is circulated between the circulators and the storage cylinders by a motor-driven pump and the primary pipework is arranged so that either circulator can be used with either storage cylinder. A by-pass with a water-flow supply relay is fitted between the primary flow and return connections of the circulator. This relay remains open until the pumps start, thus giving protection against excess temperatures in the circulator. In order to minimise the range of temperature over the whole of the storage heating period primary mixing valves are included in the primary pipework. These valves also enable water of any desired temperature to be passed to the top of the storage cylinders so that, in emergency, hot water is available for use even though the bulk of the stored water is at a low temperature. These valves are electrically-operated by thermostats and solenoids, and provide for the recirculation in the heaters until the water temperature reaches a predetermined level. The temperature of the water circulating through the radiator system and air-conditioning heater batteries is controlled by separate solenoid-operated thermostatically-controlled mixing valves.

Protective devices are provided to guard against both electrical and hydraulic faults, such as out of balance load, excess current, excess temperature, excess pressure, and failure of pump motors. The occurrence of any of these faults is shown by indicating relays on the indicating board. These relays are provided with lock outs, so that the circulators cannot be reconnected to the supply until the fault is cleared. The indicating board is made up of three panels. The centre panel carries a twenty-point electric indicating thermometer for ascertaining the air temperature in various parts of the building and the water temperature at numerous points on the primary and secondary pipework. This part of the panel also carries indicating lamps to show which heating and air-conditioning pump and fan motors are in use. On the lower part of the panel is a temperature recorder which gives a continuous record of the temperature of the flow and return water in the secondary circulating system. The two side panels, one for each circulator, carry ammeters and voltmeters, a fault indicator and a kilowatt-hour meter and recorder, together with a push-button for starting.

A main substation, equipped with a seven-panel 6·6-kV metal-clad board, is placed adjacent to the boiler house and is equipped with circuit-breakers controlling the power supply to the electrode circulators and to two 300-kVA 6,600/400-volt transformers, which supply auxiliaries and the general house service. The hot-water service throughout the building is provided by standard General Electric storage water heaters of the self-contained cistern type.

The consulting engineer was Mr. J. Roger Preston, and the installation work was carried out by Messrs. V. Smith and Company (Heating Engineers). We have to thank Mr. R. Illingworth, chief engineer of the Poplar Borough Council Electricity Department, for permission to give the above information.

BRITISH STANDARD SPECIFICATIONS.

The following specifications of engineering interest have been issued by the British Standards Institution. Copies are obtainable from the Publications Department of the Institution, 28, Victoria-street, London, S.W.1, and, unless otherwise stated, the price is 2*s.* net, or 2*s.* 3*d.* including postage.

Flame-Proof Electric-Lighting Fittings.—A specification for flame-proof electric-lighting fittings for use in coal mines and other places where inflammable gas or vapour may be present in the surrounding atmosphere has recently been issued. It is designated No. 889-1940, and covers well-glass fittings and bulkhead fittings fixed in places in which methane, petroleum or acetone vapour, or town gas or coke-oven gas, containing not more than 60 per cent. of hydrogen, may occur in explosive mixture with air. Portable hand lamps, connected to the circuit by flexible cord, are not provided for in the specification, as such lamps are not at present accepted for certification by the testing authority. The dimensions of the fittings are very carefully specified, and durability and static hydraulic, impact, resistance to thermal shock, and temperature-rise tests are provided for. It is laid down that the design and construction of the flame-proof assembly shall conform to the requirements of specification No. 229, which is entitled "Flame-Proof Enclosures for Electrical Apparatus and Tests for Flame-Proof Enclosures."

Portland Cement.—A seventh revision of specification No. 12, which deals with Portland cement, has recently been issued. Two principal changes have been made in the publication. The first is the amplification of the specification to include cement of the rapid-hardening type for which previously there had been no specification. The second change is the replacement of the test for determining the tensile strength of a standard briquette by a compression test on a cement-sand mortar cube. The desirability of making this change was mentioned in the foreword to the previous (1931) edition. Since that date the compression test has been the subject of further investigation, both at the Building Research Station and also by a panel of authorities on the subject. It has been found to give more consistent results than those obtained by the tensile test, while another advantage is that the strength of the mortar cubes can be related to that of concrete made with the same cement. The cement-mortar cubes are compacted in a specially-designed vibration machine which is fully described and illustrated in the specification. It may be mentioned, however, that the tensile test has been retained for use when specially required.

BOOKS RECEIVED.

Power Factor Problems in Electricity Supply. An Elementary Treatise for Students, Supply Engineers and Power Users. By G. W. Stubbings. New York: The Chemical Publishing Company, Incorporated. London: E. and F. N. Spon, Limited. [Price 8*s.* 6*d.* net.]

The 1940 Heat Drop Tables. Based on the 1939 Callendar Steam Tables. H.P., 100 to 3,200 lb./sq. in. Gauge. L.P., 14 to 19 lb./sq. in. Absolute. Calculated by Scientific Computing Service Limited. Published for The British Electrical and Allied Manufacturers' Association. London: Edward Arnold and Company. [Price 15*s.* net.]

The Association of Engineering and Shipbuilding Draughtsmen. Dished Ends and Stayed Surfaces. By C. C. Pounder. 1 Links-road, Epsom, Surrey: The Draughtsman Publishing Company, Ltd. [Price 2*s.* net.]

Ministry of Supply. Iron and Steel Control. Booklet No. 3. *Distribution of Steel Supplies.* London: Iron and Steel Control, Ministry of Supply, Steel House, Tothill-street, Westminster, S.W.1.

The Health and Efficiency of Munition Workers. By Dr. H. M. Vernon. London: Oxford University Press (Humphrey Milford). [Price 8*s.* 6*d.* net.]

United States Bureau of Mines. Technical Paper No. 612. *Explosion Hazards in Storage-Battery Rooms.* By G. W. Jones and others. Washington: Superintendent of Documents. [Price 10 cents.]

United States Bureau of Mines. Bulletin No. 424. *Mineral Industries Survey of the United States. California. Tuolumne and Mariposa Counties. Mother Lode District (South). Mines of the Southern Mother Lode Region.* Part II. *Tuolumne and Mariposa Counties.* By C. E. Julihn and F. W. Horton. Washington: Superintendent of Documents. [Price 60 cents.]

Department of Scientific and Industrial Research. The Investigation of Atmospheric Pollution. Twenty-Fifth Report. *Report on Observations in the Year Ended 31st March, 1939.* London: H.M. Stationery Office. [Price 2*s.* 6*d.* net.]

PERSONAL.

Mr. William Burrows, A.M.I.Mech.E., has been elected honorary secretary of the Liverpool Engineering Society, in succession to Mr. Vernon L. Farthing. Mr. E. B. Cole, M.Sc., has succeeded Dr. R. H. Grundy as Editor of the *Transactions* of the Society.

Messrs. A. Boake, Roberts and Company, Limited, chemical manufacturers, have taken offices at "Ellerslie," Buckhurst Hill, Essex.

Mr. George Claxton, hitherto works manager of Messrs. Joshua Bigwood and Sons, Limited, Wolverhampton, has been appointed to an administrative position in the firm of Messrs. Nortons (Tividale), Limited, Tividale, Tipton, Staffs.

Messrs. A. C. Wickman, Limited, Coventry, have opened a branch office at Lloyds Bank-chambers, Vicar-lane, Leeds, 1.

Mr. Sidney B. Haslam, M.I.Mech.E., M.I.E.E., has been elected President of the South Wales Institute of Engineers for the forthcoming session.

Mr. J. Scholes, who has served as chief engineer of the Consett Iron Company, Limited, for the past 21 years, has retired.

The Institution of Heating and Ventilating Engineers have removed their offices from Russell-square, W.C.1 to 21, Tothill-street, Westminster, London, S.W.1. (Telephone WHItehall 9609.)

Mr. J. Foster King, C.B.E., is retiring from the position of Chief Surveyor of the British Corporation Register of Shipping and Aircraft, 14, Blythswood-square, Glasgow, C.2, on November 30. He joined the staff of the society as leading surveyor on December 1, 1890, became assistant chief surveyor in March, 1892, and has held his present appointment for 37 years. Mr. J. L. Adam, the present assistant chief surveyor, has been appointed to succeed Mr. Foster King, and Mr. G. M. Sellar, B.Sc.(Eng.), the principal engineer surveyor, will become chief engineer surveyor.

TENDERS.

We have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Electric Overhead Travelling Crane, 40-ton, three-motor, for Hororata Substation. Public Works Department, Wellington, N.Z.; November 28. (T. 22,012/40.)

Miscellaneous Hardware required for the South African Police, including badges, buttons, buckles, numerals, spurs, handcuffs, whistles, stop-watches, revolvers, and horse and mule shoes. Union Tender and Supplies Board, Pretoria; November 21. (T. 22,056/40.)

Water-Pumping Units. With reference to the call for tenders for electric motor-driven centrifugal pumps and electrical equipment for the Municipal Waterworks on the Vaal River, at Riverton, South Africa, noted on page 248, *ante*, we now learn that the City of Kimberley has extended the closing date from October 31 until November 21. (T. 21,800/40.)

The Rubber Industry of British Malaya.—Exports of rubber from British Malaya totalled 64,712 tons during August.

British Property in France.—We are informed that the Register of British Property in Enemy Countries, which the Board of Trade is establishing, does not extend to property in enemy-occupied territory, but only to that in Germany or Italy. In these circumstances, it has been arranged with the Board of Trade, in respect of such property situated in France, that the Board will take over the results of the Register being compiled by the British Chamber of Commerce, Paris, when completed. The Board will hold these results against the time at which it should prove possible to enter into arrangements for restitution. It is emphasised that this step is being taken solely with a view to facilitating whatever arrangements may be found possible after the war. It is, moreover, stated that entry on the Register of any claim will not imply any recognition of its validity or constitute any guarantee that it will eventually be supported by H.M. Government. Persons of British nationality, resident in the United Kingdom of Great Britain and Northern Ireland, and companies registered therein, desirous of registering real and personal property situated in France, should apply for the necessary forms to the Claims Committee, British Chamber of Commerce, Paris, Inc., 22, Old Queen-street, London, S.W.1. The Register applies to Occupied and Unoccupied France, Corsica, Algeria, the French Zone of Morocco, French Somaliland, and the Principality of Monaco.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Plans which have been evolved to help the export districts to overcome the effects of the loss of trade were again under close consideration. The scheme to place a levy of 6*d.* a ton on all coal raised in Great Britain to assist the export districts was again considered in London. It was explained in South Wales that the levy would be met by a proportionate increase of price to the consumer. It has been estimated that the levy will produce about 5,000,000*l.* a year and will be distributed to each colliery undertaking to the extent that its percentage share of the national disposals was less than it was in the corresponding period of last year. Another factor that was being carefully considered was the proposal to transfer unemployed miners to other coalfields. Every effort was being made to arrange the labour supply in the South Wales coalfield to the best advantage before embarking on the wider scheme. Some collieries in the steam-coal area were still in need of men. This was particularly so in the Monmouthshire area, where high-volatile coal is mined which is very suitable for industrial uses and for which there is a sustained demand. A fairly good inquiry has been passing on the steam-coal market from the inland section but the demand from overseas remained at a low level. Nevertheless, collieries were able to maintain operations at the pits on quieter lines, and, with surplus stocks kept within reasonable limits, the tone was very steady. Best large descriptions were moving off steadily and the sized qualities were in sustained request but were not easily secured over some considerable time ahead. Bituminous smalls were still very scarce for early delivery, but offers of dry smalls were freely made. Cokes were busy but patent fuel remained slow.

The Iron and Steel Trade.—Activity was well maintained in the iron and steel and allied trades of South Wales and Monmouthshire last week. Most works were engaged almost to full capacity on orders already on their books and with the demand well sustained the forward outlook appeared favourable.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel trade have shown no change during the week, and with a plentiful supply of raw material available, production has been maintained at full capacity. Government work is still the main source of the current business. From the shipbuilding yards, munition works, constructional engineers, sheet workers, etc., there is a heavy demand for supplies, and deliveries are such that practically all are being kept running at full capacity. The black steel sheet makers have as much work on hand as they can conveniently handle, and the demand covers both plain and galvanised varieties. Makers of containers of all descriptions are very busy, and their requirements represent a substantial tonnage. The following are the current quotations:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton medium plates, rolled in sheet mills, ¼ in. and thicker, 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised sheets, plain, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton, and corrugated, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

Malleable-Iron Trade.—The demand for bar iron continues to be very good, and the West of Scotland malleable-iron makers are very well placed for business at present. The recent scarcity of suitable scrap has been overcome, and although stocks are not heavy, they are sufficient for the present and immediate future requirements. The re-rollers of steel bars are also fairly well off for raw material, as considerable tonnages of semies have recently come into port. The demand for re-rolled bars is very heavy and the present orders represent a tonnage sufficient to keep makers fully occupied for many months. Current quotations are as follows:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; re-rolled steel bars, tested, 15*l.* 11*s.* 6*d.* per ton, and untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton.

Scottish Pig-Iron Trade.—No change has to be recorded in the state of the Scottish pig-iron trade this week, and with ample supplies of iron ore, all the furnaces are operating at full capacity. The current output is going rapidly into consumption, and consumers are pressing for supplies. The demand for foundry grades of iron, however, is only fair.

GRAVING DOCK, SYDNEY HARBOUR.—The Australian Government has appointed Sir Alexander Gibb and Partners to supervise the construction of the new graving dock in Sydney Harbour, the estimated cost of which is 3,000,000*l.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The large production of iron and steel is passing promptly into use and the demand is increasing. The output of several commodities is at a record level. Obstacles to an enlargement of the make are being overcome and licences for supplies of most commodities are on an improved scale. Although pressure for delivery of material for Government requirements is unabated, the release of an increasing tonnage for ordinary industrial requirements is expected. Raw materials and semi-finished products continue to be plentiful and this enables the heavy output of finished commodities to be maintained.

Cleveland Iron Trade.—Deliveries of foundry iron remain quite satisfactory. Cleveland pig is still scarce, but adequate supplies of Scottish iron are coming to hand for specific use and Midland brands are arriving in substantial parcels at North East Coast foundries. There is still no prospect of a material enlargement of the light and irregular make of Cleveland pig, the shortage of which, however, is of little importance. The fixed prices of Cleveland qualities are based on No. 3 description at 120*s.*, delivered within the Tees-side zone.

Hematite.—There has been a slightly increased make of East Coast hematite, and this, with imports of American hematite, promises to provide tonnage sufficient for consumers' needs. The heavy make of local iron is absorbed as it becomes available. Buyers are calling for full contract supplies and the large and expanding tonnage absorption of the makers' own consuming departments is accounting for the whole blast-furnace output. Second hands still hold moderate parcels, but are unable to comply fully with the requests of their customers. The recognised market values are ruled by No. 1 grade of hematite at 131*s.*, delivered to North of England areas.

Basic Iron.—There is still no saleable Tees-side basic iron, the price of which remains nominal at 113*s.* The whole of the present output is required for the makers' adjacent steelworks.

Foreign Ore.—Stocks of foreign ore are considerably above the quantities usually held and unloadings are regular and substantial.

Blast-Furnace Coke.—Business in Durham blast-furnace coke is of little account. The supply is plentiful but sellers have disposed of as much tonnage as they consider to be advisable and local users are virtually off the market, having covered their requirements well ahead. Stabilised quotations remain at the equivalent of good medium qualities at 32*s.* 5*d.* at the ovens.

Manufactured Iron and Steel.—The make of semi-finished iron and steel is maintained at a satisfactory level and, with the heavy imports of bars, billets and blooms from the United States, there is ample tonnage for the re-rolling mills. Heavy-steel makers are turning out large quantities of material to meet the unabated pressure for delivery. Distribution of all classes of steel is carefully controlled. Soft steel billets are quoted, 10*l.* 10*s.* to 10*l.* 15*s.*; hard billets, 11*l.* 17*s.* 6*d.*; joists and angles, 13*l.* 13*s.*; heavy plates, 14*l.* 3*s.*; and boiler plates, 15*l.* 0*s.* 6*d.*

Scrap.—Ample supplies of iron and steel scrap are now available and some grades are offered in larger quantities than the works can accept.

AMERICAN BUREAU OF SHIPPING.—It was announced during the course of the recent half-yearly meeting of the American Bureau of Shipping that in the first six months of the present year 24 new ocean-going ships, aggregating 161,026 gross tons, and 30 existing vessels, making together 131,820 gross tons, were classed by the Bureau. Small craft and barges brought the total of vessels classed for the six months ending June 30, 1940, up to 330,573 gross tons.

THE INSTITUTION OF SANITARY ENGINEERS.—The Organising Committee of the Institution of Sanitary Engineers has decided to defer the holding of sessional meetings for the time being. It is hoped, however, to print, in a forthcoming issue of the *Bulletin* of the Institution, the paper by Colonel Mackenzie on "Water Sterilisation—The Choice of Method," which was to have been read at a meeting fixed for September 27 but subsequently cancelled.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The Council of the Institution of Automobile Engineers has awarded the Crompton Medal, for the best paper read before the senior section of the Institution, during the 1939-40 session, to Dr. J. S. Clarke, author of the contribution "The Use of Gas as a Fuel for Motor Vehicles." A Graduates' Prize of 8*l.* has been awarded to Mr. J. F. Norwood, of the Luton Branch, and another of 5*l.* to Mr. F. W. Judd, of the London Branch of the Institution.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, October 12, 2.30 p.m., The Engineers' Club, Manchester. Presidential Address, by Mr. A. C. Dean.

INSTITUTION OF CIVIL ENGINEERS.—*Yorkshire Association:* Saturday, October 12, 2.30 p.m., The Grand Hotel, Sheffield. Ordinary Meeting. Chairman's Address, by Mr. A. G. Beaumont.

BRADFORD ENGINEERING SOCIETY.—Monday, October 14, 7.15 p.m., The Technical College, Bradford. Presidential Address, "The History of the Woolcombing Machine," by Mr. H. Baxter.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—Tuesday, October 15, 6.30 p.m., The Lighting Service Bureau, 2, Savoy-hill, W.C.2. Presidential Address, by Mr. H. W. Swann.

IRON AND STEEL INSTITUTE.—Tuesday, October 15, 7.30 p.m., The Modern School, Cole-street, Scunthorpe. Joint Meeting with THE LINCOLNSHIRE IRON AND STEEL INSTITUTE. Discussion on "Anti-Piping Compounds and Their Influence on Major Segregation in Steel Ingots," by Dr. E. Gregory.

INSTITUTE OF FUEL.—Thursday, October 17, 2.15 p.m., The Connaught Rooms, Great Queen-street, Kingsway, W.C.2. Presidential Address, by the Acting President, Mr. W. M. Selvey.

INSTITUTION OF MECHANICAL ENGINEERS.—*Midland Branch:* Thursday, October 17, 6 p.m., The James Watt Memorial Institute, Birmingham. "The Engineering Aspect of Gas-Fired Industrial Furnaces," by Dr. J. S. Clarke. *North-Western Branch, Graduates' Section:* Thursday, October 17, 7 p.m., The Engineers' Club, Manchester. Annual Lecture. *Institution:* Friday, October 18, 2.30 p.m., Storey's-gate, St. James's Park, Westminster, S.W.1. General Meeting. Presidential Address, "Mainly the Port of London," by Mr. Asa Binns.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, October 18, 6 p.m., The Literary and Philosophical Society, Newcastle-upon-Tyne. Annual General Meeting. Presidential Address, by Mr. W. A. Woodeson.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The resources of the steel-producing sections are being severely taxed, but the raw material position is satisfactory, and deliveries of pig iron are good; ample supplies of scrap are available. There appears to be a temporary shortage of some types of finished steel, but inquiries show that larger supplies will soon be available. There is an extensive demand for basic steel. Buying is chiefly on inland account, only a limited tonnage going abroad. Owing to the heavy demand for high-efficiency steels, especially for Government purposes, steel-making alloys are in particularly strong request. Record tonnages of manganese steel are being produced, this material being used in large quantities for the manufacture of coal-breaking machinery parts, crusher rolls, crusher cones, dredger tumblers, corner plates, etc., elevator buckets, hydraulic pump parts, and railway and tramway special track work. The heavy-machinery and engineering branches are very busy. Large consignments of ship steel, forgings and castings, auxiliary machinery, and deck furnishings are continually leaving local works for associated shipyards. Grinding and crushing plant are in strong demand, while orders for electrical plant and pumping equipment are more numerous. The home demand for engineers' small tools, machine parts, machine knives and tools, is brisk, and farm and garden tools are a progressive section.

South Yorkshire Coal Trade.—No material change has taken place in the coal position generally. Collieries are operating at full capacity and stocks are being accumulated to offset a winter shortage. Industrial coal is in stronger demand, but locomotive fuel is in less active request. Small coal is being consumed in large tonnages by electric power stations. The house coal market is more active, and foundry and furnace cokes are in strong demand.

CONTROL OF PLASTICS.—The Minister of Supply has issued an Order, entitled the Control of Plastics (No. 1) Order. Plastics in the form of moulding powder, in the production of which formaldehyde, phenol, cresol, urea, thio-urea, or cellulose acetate have been used, may not be bought, sold, or used except under licence. Communications should be addressed to the Ministry of Supply, Plastics Control, Great Burgh, Epsom, Surrey.

MECHANICAL COMPARATOR.

MESSRS. SIGMA MANUFACTURING COMPANY, LIMITED, LETCHWORTH.

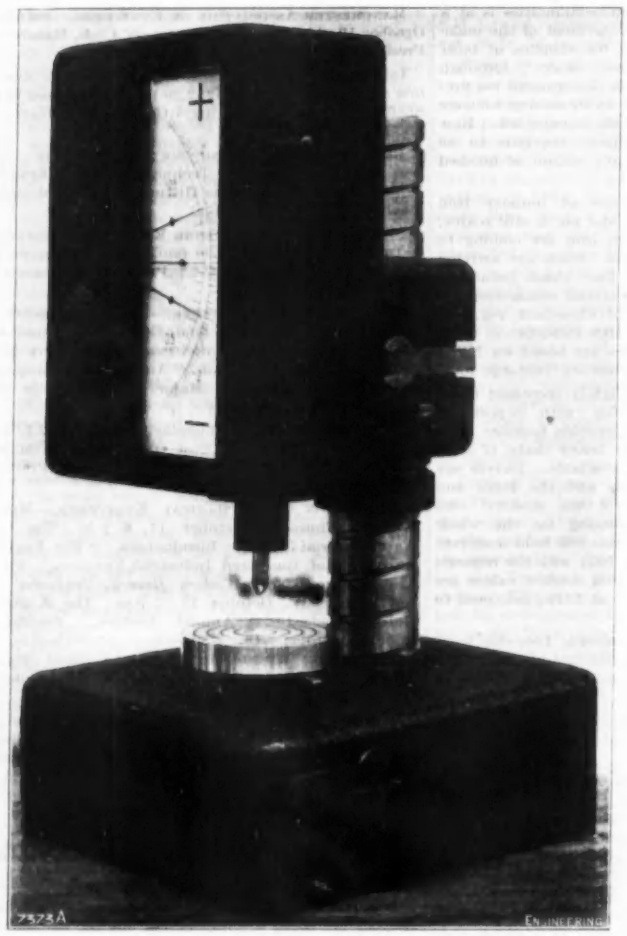
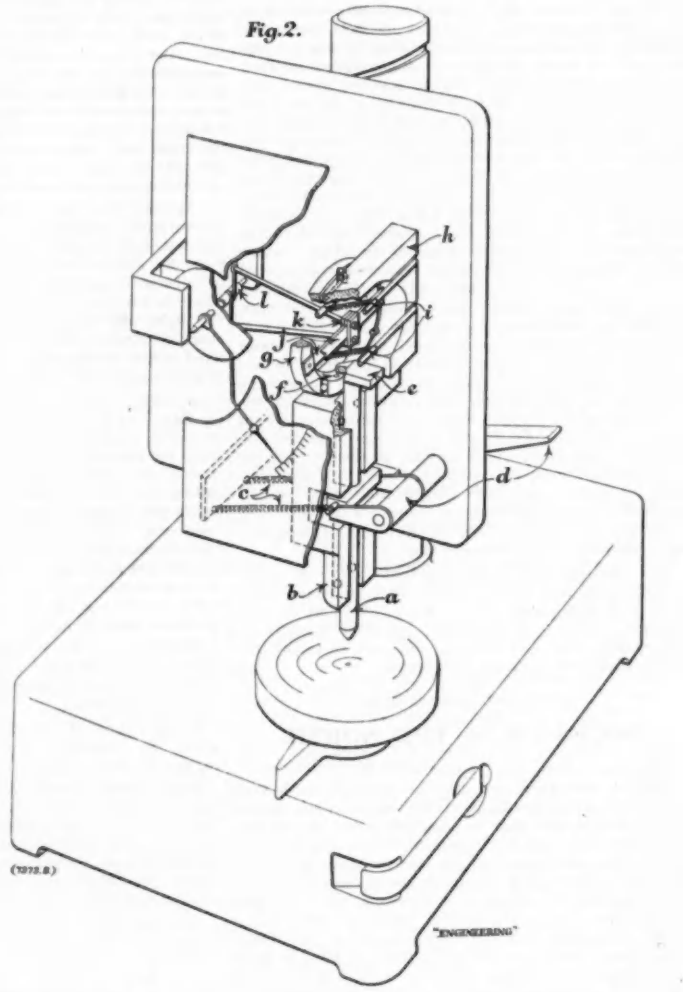


Fig. 1.

Fig. 2.



THE "SIGMA" MECHANICAL COMPARATOR.

The mechanical comparator shown in the accompanying illustrations, Figs. 1 and 2, has, apart from its intrinsic interest, a certain significance as it represents a second successful attempt to enter a field which the firm of Messrs. Carl Zeiss, Jena, have exploited for some time, the other attempt in this direction being represented by the O.T.M. circular optical table described on page 166, *ante*. The comparator, which is designed to replace the Zeiss Orthotest, is manufactured by Messrs. Sigma Manufacturing Company, Limited, Letchworth, and makes possible the accurate and rapid inspection by unskilled labour of parts which require to be interchangeable and therefore must not exceed definite tolerances, such parts, moreover, being usually made by mass-production methods and thus requiring that their checking shall be carried out expeditiously. It will be clear from the external view, Fig. 1, that measurements are made between an anvil mounted on the base and a conically-pointed spindle which automatically actuates a pointer needle moving over a quandrantal scale between predetermined limits indicated by two adjustable pointers. The spindle is spring controlled to make the reading contact and is lifted to allow the work to be inserted by the short lever seen near the bottom of the dial casing at the right of the illustration.

The dial casing can be adjusted for height on the supporting pillar so as to admit work up to 4 in. high, but it will be obvious that for deeper work the pillar can be supplied to suit. The circular anvil can be adjusted for height by the single wing nut seen below it and both the anvil and the dial casing can be locked in any position by means of spring-controlled draw bolts actuated by cam levers, which levers can be readily identified in Fig. 1. The throat depth, *i.e.*, the distance between the centre of the spindle and periphery of the pillar, is 3½ in. The scale has a reading range of 0·006 in., and will check work within tolerances of ± 0·003 in. The limit pointers shown in the illustration are set as required by the two knurled knobs on the front of the casing at the left. The single knob at the right side of the casing is for setting the scale itself to give zero reading on the master piece. A secondary scale graduated to read to ± 0·05 mm., is shown in Fig. 1.

The construction of the instrument will be clear from the isometric view, Fig. 2. The spindle *a* is not carried in a sleeve, but, in order to minimise friction, is guided by four balls lying in a hardened and ground channel *b*. A crosshead formed about half way up the spindle carries a pair of tension springs *c*, which are anchored at their other ends to the casing. These serve not only to keep the spindle truly in its groove, but, since the point of anchorage is below the point of attachment, set up a downward pressure so that the contact of the spindle point is definite and constant. The spring tension is overcome, when work is to be inserted and removed, by the relieving mechanism *d*, which consists of a finger lever and a forked lever, the latter acting on the spring pins on the crosshead.

The top of the spindle is furnished with a head *e* extended on the inside to bear on a ball *f* fitted in a recess in a floating ring *g*, contact being always ensured when the work is in place by the downward pull of the springs *c*. The ring, though referred to as "floating," is not entirely free, but is connected to a fixed horseshoe frame *h*. Both the ring and frame are formed on their outer surfaces with a pair of vee-grooves, in which lie small rods, these rods running horizontally. The rods on the frame are connected with those on the ring by a pair of tension springs *i*, set at an angle such that an upward pull is exerted on the ring. The ring and frame have, moreover, three vertical vee-grooves on their inner surfaces, the grooves being fitted with balls. The ring can, therefore, move in a vertical plane relative to the frame, but the tension springs and the balls prevent movement either away from one another or in a horizontal plane. The ring and frame are, further, connected in another way: To the inner face of each is attached a thin strip of spring steel *j*. Both springs are rigidly held together at the centre by the clamp *k*, which carries a pair of diverging arms. The ends of these arms are connected by a thin steel ribbon, which passes round a barrel *l* on the spindle carrying the indicating pointer. The disc seen to the left of this barrel is of aluminium and is situated between the poles of a permanent magnet, this arrangement damping out any oscillation of the pointer which might otherwise arise from very rapid movements. The magnification of the pointer movement compared with that of the spindle is 1,000 to 1.

The action of the mechanism may now be referred to. When the spindle is lifted, either by the insertion of a component being checked or the manipulation of the lever *d*, the tension springs *i* cause the ring also to move upwards, the mutually opposing springs *c* and *i* maintaining contact between the spindle and ring. But the upward movement of the ring causes displacement of one of the flat springs *j* relative to the other, both springs being stretched tautly across the gaps concerned. The vertical movement is arrested by these springs twisting through an angle proportional to the vertical displacement. In the meantime, the degree of twist has been transferred to the spindle of the indicating pointer by the tilting of the arms of the clamp *k*, and the pointer shows by how much the thickness of the work departs from that of the master piece. The principle and construction adopted in this new instrument are both ingenious, and there seems to be little chance of wear taking place to an extent likely to render it inaccurate after considerable use. Friction is almost absent, all relative sliding motion taking place on steel balls and not on flat surfaces, while the spindle of the indicating pointer is carried in jewelled bearings. The manufacturers claim that exhaustive tests have shown that the Sigma Comparator may be confidently regarded as an efficient alternative to the Zeiss Orthotest. The Comparator is distributed in this country by Messrs. E. H. Jones (Machine Tools), Limited, Edgware-road, The Hyde, London, N.W.9.

WELDED RIGID-FRAME FACTORY BUILDING.

(*For Description, see Page* 281.)

Fig.5. (*a*)

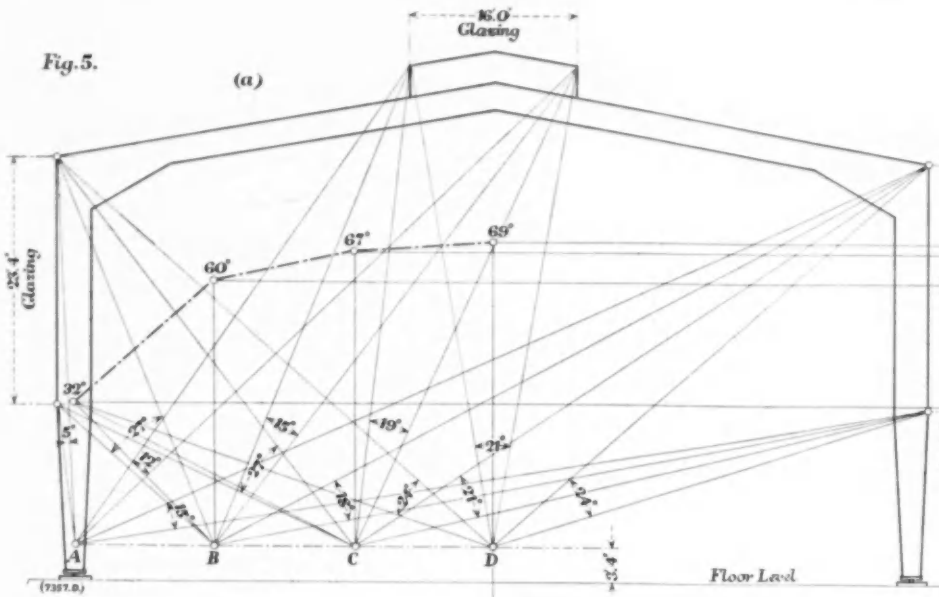


Fig.6. (*b*)

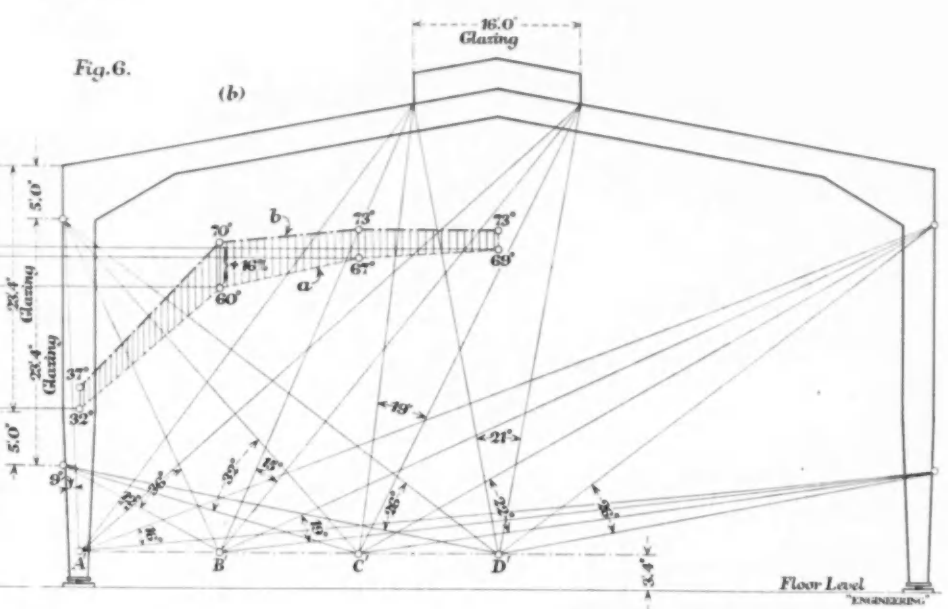


Fig.7.

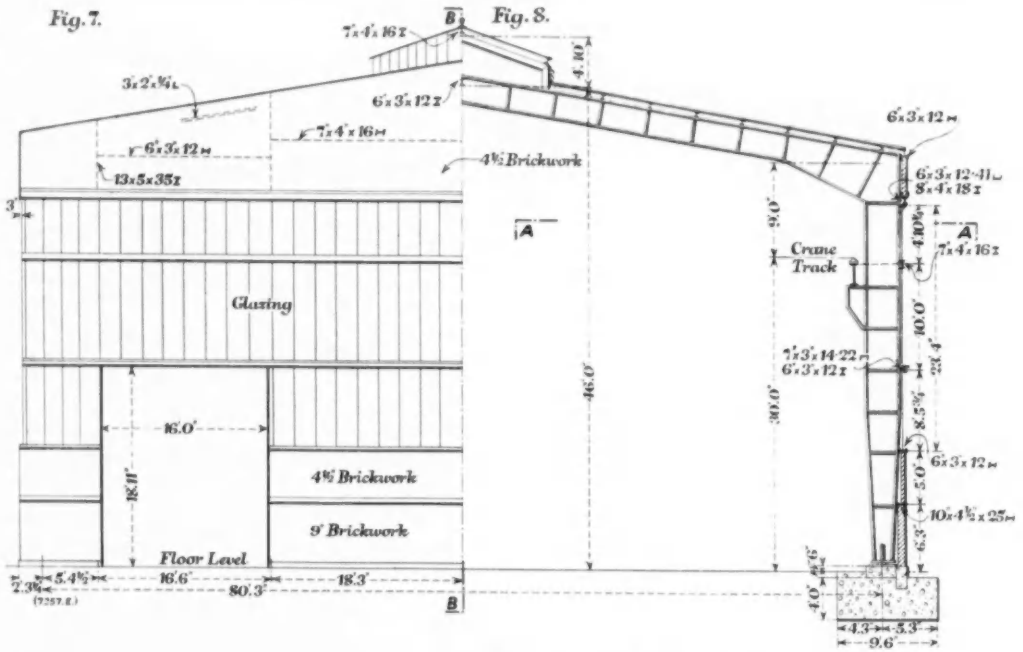


Fig.8.

Fig.11.

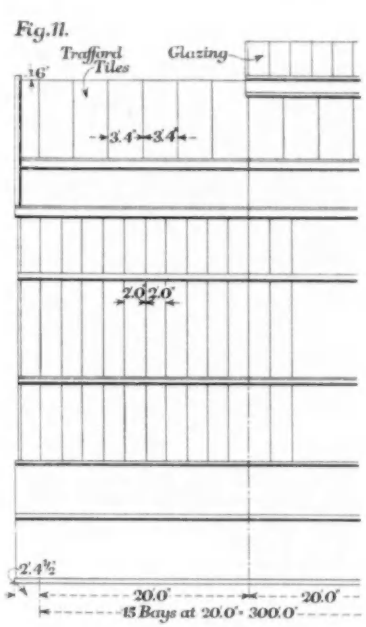


Fig.12. SECTION BB

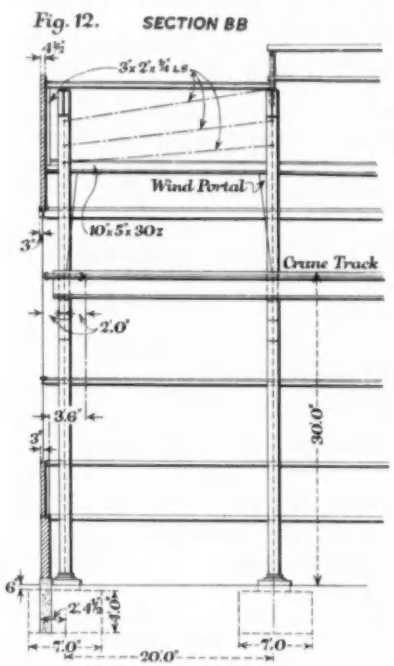


Fig.9.

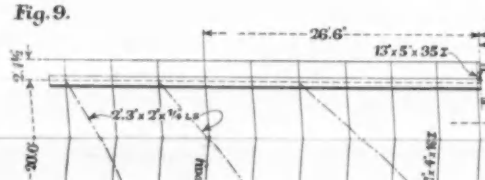


Fig.10. SECTION AA

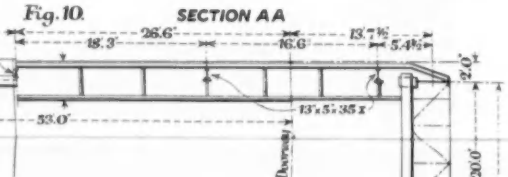


Fig.13.

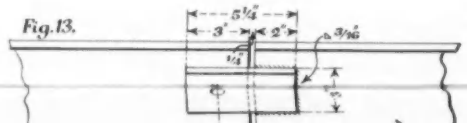


Fig.14.

2.3"x2"x½" L.s
C.I. Doorway
6"x3"x12 I
20.0'
4.0'
13.0'
3.0'
53.0'
13"x5"x35 I
C.I. Doorway
Diagonals and Verticals
3½ O.D.x 7G. Tubes
4.6%
20.0'
15 x 20.0" = 300.0'

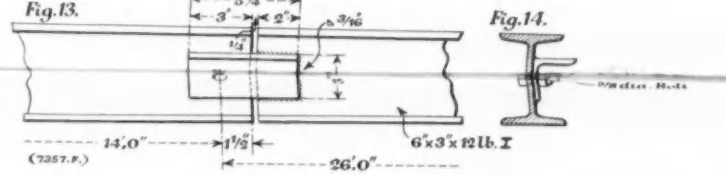


Fig.13.
3"
2"
3/16
¼
14'.0"
1½"
26'.0"
6"x3"x12 lb. I
(7357.F.)
Fig.14.

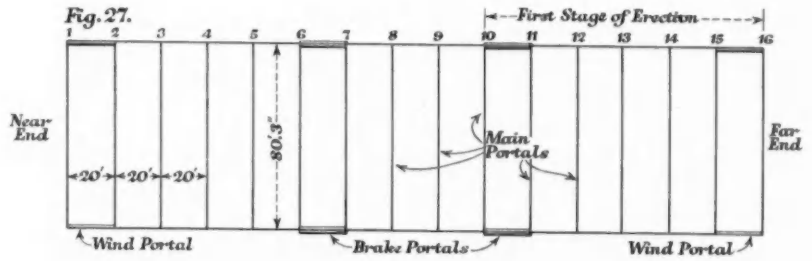


Fig.27.
First Stage of Erection
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Near End
Far End
20' 20' 20'
80'.3"
Main Portals
Wind Portal
Brake Portals
Wind Portal

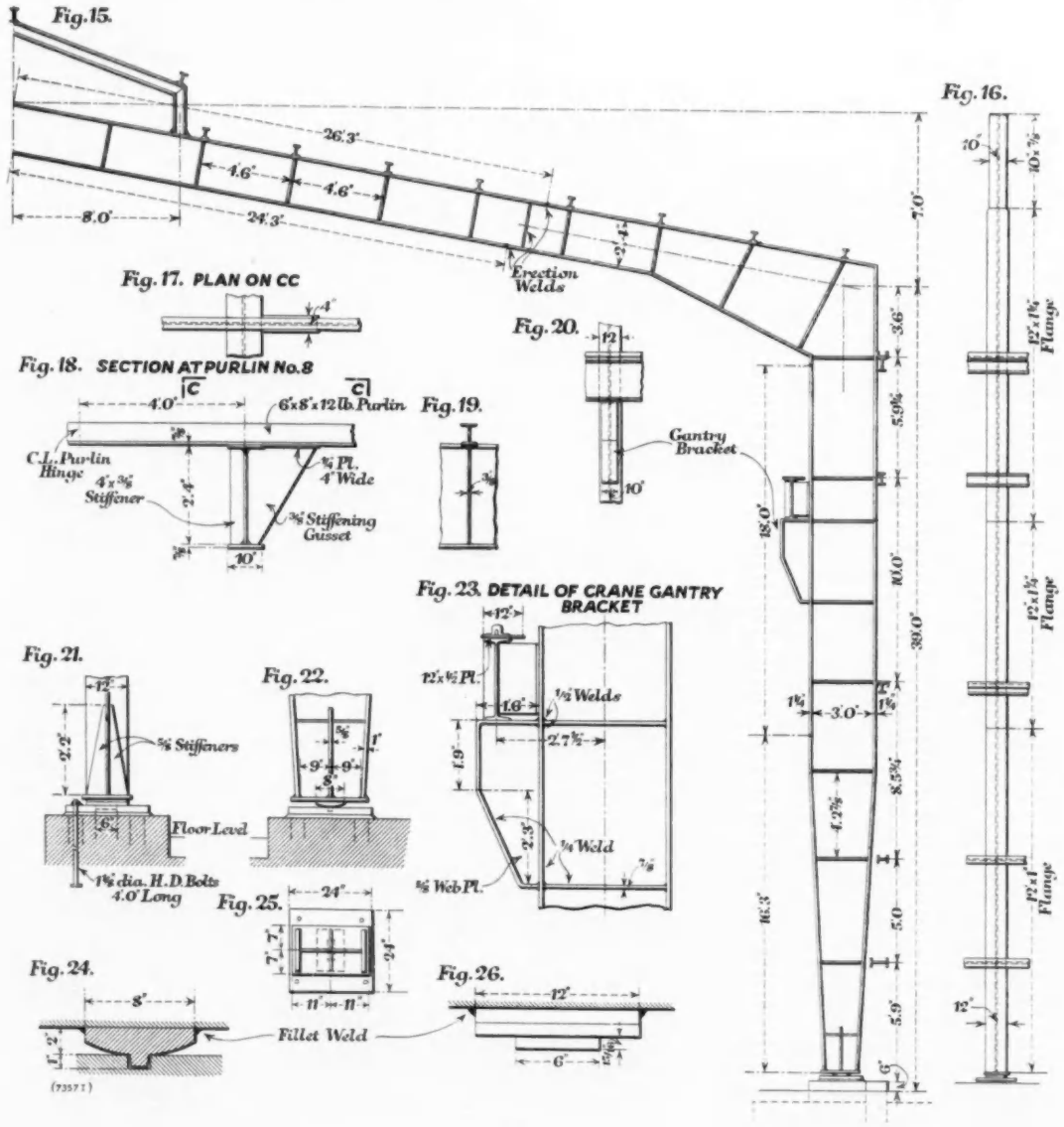


Fig.15.
26'.3"
4.6'
4.6'
8.0'
24'.3"
Erection Welds
Fig.16.
10'
10'.⅜
12"x1⅛" Flange
7'.0"
3'.6"
5.9%
18'.0"
10'.0"
39'.0"
1⅛
3'.0"
1⅛
4.2%
8.3%
5.0'
5.9'
6"
12"x1½" Flange
12"x1" Flange
12"
Fig.17. PLAN ON CC
4"
Fig.18. SECTION AT PURLIN No.8
C
C
4'.0"
6"x8"x12 lb. Purlin
C.L. Purlin Hinge
4"x⅜" Stiffener
⅜" Pl. 4" Wide
⅜ Stiffening Gusset
2'.4"
10"
Fig.19.
⅜
Fig.20.
12"
Gantry Bracket
10"

Fig.21.
12"
2'.2"
⅝ Stiffeners
6"
Floor Level
1⅛" dia. H.D. Bolts 4.0' Long

Fig.22.
⅝"
1"
9"
9"
8"

Fig.23. DETAIL OF CRANE GANTRY BRACKET
12"
12"x½" Pl.
1'.6"
½" Welds
2'.7½"
1'.9"
2'.3"
¼" Weld
⅝" Web Pl.
⅞"

Fig.25.
24"
7"
7"
24"
11"
11"

Fig.24.
8"
2"
Fillet Weld
(7357 I.)

Fig.26.
12"
6"

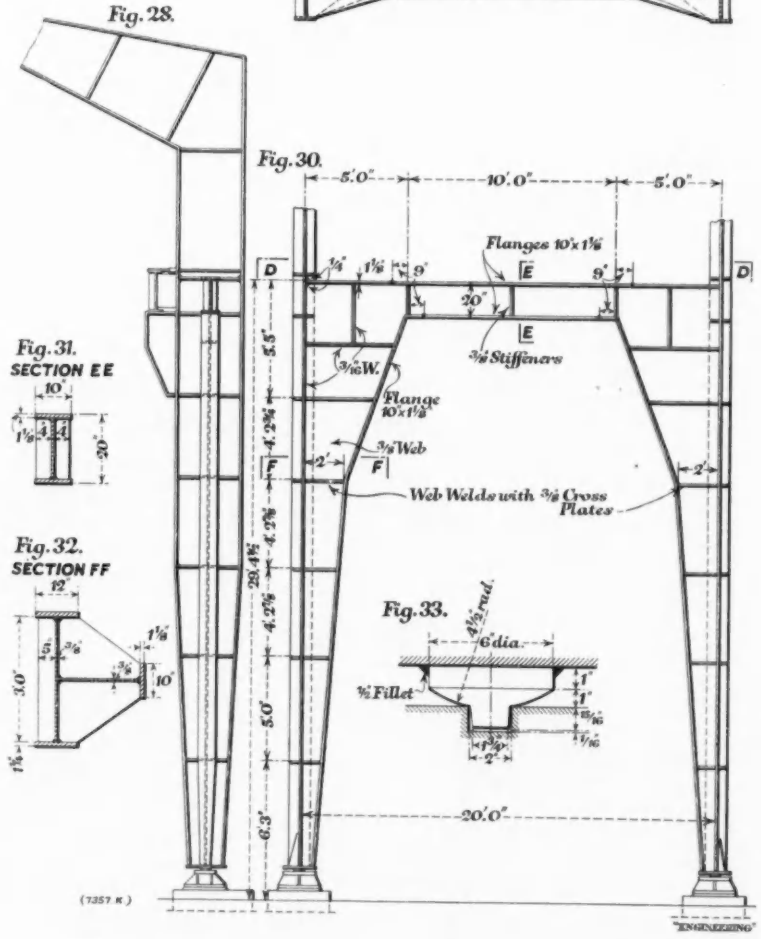


Fig.28.
Fig.29. PLAN ON DD
Fig.30.
5'.0"
10'.0"
5'.0"
Flanges 10"x1⅛"
D
E
9'
20"
⅜" Stiffeners
3/16 W.
Flange 10"x1⅛"
⅜" Web
F
2'
Web Welds with ⅜" Cross Plates
5.5'
4'.2¾"
4'.2¾"
29.4½"
4'.2¾"
5.0'
6'.3"
20'.0"
Fig.31. SECTION E E
10"
1⅛
20"
Fig.32. SECTION F F
12"
1⅛"
⅜
⅜
10"
3.0'
1⅛"
Fig.33.
4½" rad.
6" dia.
½" Fillet
1"
1"
1"
2"
(7357 K.)
"ENGINEERING"

UNIV. OF MICH.

ENGINEERING.

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ENGINEERING

FRIDAY, OCTOBER 11, 1940.

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SCIENCE AND THE WAR.

WHILE the tendency of the ill-informed to blame modern scientific development as a prime causative influence towards war seems to have succumbed to the logic of events, it is undoubtedly true that scientific advancement, like the progress of the mechanic arts, has been greatly stimulated by the pressure of war needs. If, in the course of protracted hostilities, much that is scientifically valuable may be destroyed, and much more research may be retarded or completely prevented, there is the compensating advantage that some knowledge, at least, may be more widely diffused and intensively developed than would be practicable under the ordinary conditions of peace, and its potentialities displayed in a new and powerful light, to the possible future benefit of mankind as a whole. Nor is this effect limited to any particular department of scientific endeavour: medicine, metallurgy, radiophysics, acoustics, and a dozen other branches provide examples of development directly attributable to the urgent demands of nations at war, and—it must be admitted—the consequently changed attitude towards the questions of expense that so often hamper peace-time research which can offer no obvious and immediate financial return.

It may be expected, therefore, that more than merely belligerent benefits may ultimately accrue from the decision to set up a Scientific Advisory Committee, the appointment of which was one of the last actions of Mr. Neville Chamberlain in the office of Lord President of the Council. The terms of reference of the Committee, as announced, are "(*a*) to advise the Lord President on any scientific problem referred to them; (*b*) to advise Government Departments, when so requested, on the selection of individuals for particular lines of scientific inquiry or for membership of committees on which scientists are required; and (*c*) to bring to the notice of the Lord President promising new scientific or technical developments which may be of importance to the war effort." Lord Hankey has been appointed chairman of the Committee, and the other six members, all of whom are Fellows of the Royal Society, are: Sir William Bragg, O.M., K.B.E., President of the Royal Society; Dr. E. V. Appleton, Secretary of the Department of Scientific and Industrial Research; Sir Edward Mellanby, K.C.B., Secretary of the Medical Research Council; Sir Edwin Butler, C.M.G., Secretary of the Agricultural Research Council; Professor A. V. Hill, O.B.E., M.P.; and Professor A. C. Egerton, respectively, the Biological and the Physical Secretaries of the Royal Society.

From the composition of the Committee, it will be evident that one of its most important functions will be that of liaison. The members are all eminent men in their respective spheres, and some have achieved distinction in more than one direction, but their potential value in the national war effort lies even more in their close association with other leading figures in diverse branches of scientific study. Engineering science is not strongly represented, at first sight, but, in fact, is in no danger of being ignored; Dr. Appleton, besides being secretary of the Department of Scientific and Industrial Research (which is in direct contact with all the important branches of engineering manufacture and research), is a member of the Advisory Council on Scientific Research and Technical Development, set up in December last by Mr. Leslie Burgin, the then Minister of Supply, to ensure that the large amount of scientific and technical work within the purview of his Department should be organised with due regard to the latest advances in knowledge. It was announced at the time that the Advisory Council would also "initiate new proposals for research and technical development, and make recommendations regarding the most effective use of scientific personnel." On the face of it, this might suggest the possibility of a certain amount of overlapping, but against this the composition of the two advisory bodies, and the associations existing between their several members in other spheres of activity, should provide a reasonably sufficient safeguard.

In the popular mind, an absorption with pure science is commonly regarded as evidence of detachment from those affairs which are rather loosely classed as "practical." It is of interest, therefore, to note the very considerable amount and variety of thoroughly "practical" experience possessed by the members of the new Committee, even in the specialised study of modern military conditions and needs. Lord Hankey, of course, is probably unique in the extent and intimacy of his knowledge of the higher conduct of international affairs by reason of his secretaryship of the War Cabinet, in 1916, and of the Imperial War Cabinet in 1917, and his nineteen years as Cabinet Secretary from 1919 to 1938. It should not be overlooked, too, that he served for many years in the Royal Marine Artillery, from which he retired in 1918 with the rank of lieutenant-colonel, and that he was secretary of the Committee of Imperial Defence for some 26 years. As he was also secretary of the Washington Conference of 1921, and the London Naval Conference of 1930, it may be said that he is familiar likewise with the problems of Imperial "un-defence."

The inclusion of Sir William Bragg in the Committee might be regarded as a foregone conclusion by virtue of his presidency of the Royal Society, but it is a safe assumption that his collaboration would have been sought in any event. In the words of the address which accompanied the award to him, in 1938, of the Institute of Metals Medal, his "brilliantly conceived application of X-rays to the study of the structure of matter has influenced scientific research far beyond the boundaries of the particular branch of applied science represented by this Institute." Dr. E. V. Appleton is best known for his investigations on the effect of the ionised regions of the upper atmosphere on the propagation of radio waves, conducted on behalf of the Radio Research Board, which resulted in the discovery of the layer now called by his name. He is president of the International Scientific Radio Union and chairman of the British National Committee for Radio-Telegraphy, and, during the war of 1914-18, served in the Royal Engineers with the rank of captain.

The interests of Sir Edward Mellanby and Sir

Edwin Butler have lain in directions rather apart from those which are the concern of Engineering, although medical and agricultural research alike are making contact at an increasing number of points with the problems of engineering design and construction involved in works of sanitation, water supply, and the growing mechanisation of the countryside. Professor A. V. Hill's fame is also essentially biological, yet he, too, has been closely associated with military affairs. Service experience in the Cambridgeshire Regiment of the Territorial Army, during the last war, was followed by an appointment as Director of the Anti-Aircraft Experimental Section of the Munitions Inventions Department and membership of various committees concerned with air defence; and, in 1939, he was appointed chairman of the Scientific Research Committee, set up in connection with the Central Register by the Ministry of Labour. Professor A. C. Egerton, who has occupied the Chair of Chemical Technology at the Imperial College of Science since 1936, was previously Reader in Thermodynamics at the University of Oxford for some fifteen years, and was formerly a member of the Advisory Council of the Department of Scientific and Industrial Research.

It is early to speculate on what may be the eventual outcome of the setting up of this Committee, but it would be premature to assume that, because its appointment is fundamentally a war measure, its influence will be limited to affairs arising out of the war. The establishment of the Department of Scientific and Industrial Research, and the great expansion of the work of the National Physical Laboratory, can be directly traced to the need for closer co-ordination of scientific effort disclosed by the war conditions of 1914-18 and the steps then taken to mobilise scientific resources in the national interest. The present conflict is even more truly "an engineers' war" than the previous one; but engineering advances have become increasingly dependent on research in pure and applied science, and, when "normalcy" is again restored, it may be taken as assured that the requirements of peace, also, will entail scientific co-operation on a scale materially wider than has ever obtained before.

INDUSTRIAL PREPAREDNESS.

It is probable that the remarkable industrial effort now being made by this country would have shown even better results if a comprehensive plan had been worked out in advance for the mobilisation of industry in war-time. Present conditions suggest that any such plan would probably have fallen far short of the requirements of war, but, none the less, it might have proved a useful pivot on which industry could have swung over to war production with an acceleration greater than has been possible. In saying this, it is not suggested that, in the past, the industrial demands of a major war were overlooked. The decision to set up the shadow factories, in 1936, is sufficient evidence that the necessity for industrial preparation was realised, but experience has shown that this was by no means all that was necessary. Thousands of factories, in the course of this year, have turned over to a type of production with which they were previously unfamiliar; and had they had experience, even on a small scale, of the type of manufacture to be required of them, or information on which production plans for the future could have been based, even the present remarkable outputs might have been considerably augmented.

Obviously, the preparation of effective plans providing for such a swing-over of industry would be a matter of great difficulty and complexity. At the best they could be only partial. Under such plans, a factory manufacturing, say, lawn mowers, eminently a peace-time product, would be scheduled to turn over to some form or accessory of armament suitable for production by its machine-tool capacity and its regular workpeople. The mere statement of an individual case of this kind, when it is viewed from the background of the thousands of factories and the tens of thousands of different types of manufacture, is sufficient to illustrate the stupendous nature of the problem concerned. None the less, in actual fact, the manufacturers of lawn mowers have changed over to war production; had it been possible for them to know in good time beforehand what was likely to be required of them, it is clear that the necessary modification of their activities might have been carried through more quickly and with greater ease. Although the discussion of such pre-war planning, from the point of view of this country, is only of academic interest at the present time, it is of importance to note that efforts towards such pre-war industrial planning are now being made in the United States.

In the war of 1914-18, the United States had two million men under arms. It was found that the average time of training required for these men was nine months. Initially, such equipment as rifles and mobile artillery was available for half-a-million men; the country being dependent on its Allies for the necessary supplies for the remainder. Material of United States manufacture did not come forward in quantity until the spring of 1919, that is, two years after the declaration of war, as compared with the nine months' average training of the men of the combatant forces. The possibility of the United States being engaged in a major war seems, at the present time, at least as likely as was the similar possibility on our side when the shadow factories were set up, and a concerted effort is in progress to prepare preliminary industrial plans which will enable industry to change-over to a war-time footing in less than the two years which were necessary twenty-three years ago. Although these plans have no immediate application to present British circumstances, they are of great interest from the point of view of industrial organisation, and in the future history of an imperfect world may possibly prove of direct importance.

Some particulars of the procedure which has been adopted are given in a paper by Lieut.-Colonel William C. Young, which was presented at the meeting of the American Society for Testing Materials, held in Atlantic City, in June. It is entitled "Material Standards in National Preparedness." The method followed has been the setting up of 58 Procurement Planning District organisations, spread over the country. Each organisation deals with some particular type of supply, such as ordnance, and the service required is related to the manufacturing capacity of the particular district concerned. Each district has a skeleton staff consisting of a prominent civilian business man, an executive officer of the Regular Army, and the necessary clerical staff. The executive officer surveys his district from the point of view of its potential manufacturing capacity for war material, being assisted by his civilian chief, who is chosen in view of his knowledge of the industrial field concerned. It is the practice to plan on the assumption that half the potential war manufacturing capacity of the district will be utilised, leaving the remainder to its normal activities. The purpose of this limitation is to avoid too great a dislocation of the business links of the various firms concerned and to facilitate a return to normal conditions at the end of the war. By means of this method of Procurement Planning Districts, some 20,000 industrial plants have now been surveyed and 10,000 selected as potential producers of war material.

It is clear that the information collected in this way will be of considerable value in giving the military and naval authorities a working idea of the possible war-time capacity of American industry, but it does not give any indication of the time which may be required for the necessary change-over. Matters have, however, been carried considerably farther. A detail survey has been made of the machine-tool equipment and other features of selected plants and accepted schedules of production have been signed by certain manufacturers. These do not constitute contracts for supplies, but are merely agreements by the manufacturers that they will play a particular part in a war programme. Even this, however, does not give the factories experience in the production of material which may be very different from that with which they are normally concerned, and a system of actual manufacture on a small scale has been introduced. A series of "educational orders," 105 in number and covering 58 items of a strictly non-commercial nature, has been placed. Although these orders cover relatively small quantities of material, it is specified that they shall be carried out by quantity-production methods, thus enabling experience to be gained which will greatly facilitate a possibly necessary change-over to production on a war scale. It is estimated that the experience provided by these educational orders will enable production on a large scale to be commenced some 4 months to 12 months earlier than would be possible were the manufacturers entirely unfamiliar with the new types of articles they were required to produce.

Experience in this country suggests that, in the event of engagement in a major war under modern conditions, the United States would find this programme in itself to fall short of requirements. Particularly, the suggestion that 50 per cent. of commercial industry should be left to its normal activities would probably prove an impossible ideal. This is not to say, however, that these preliminary studies or activities would not prove of distinct value; they might well enable the country to take effective military action on a large scale at a considerably earlier date than would otherwise be possible. Even in the event of the United States avoiding the catastrophe of war, the work which is being done will clearly prove of direct value in connection with the vast armament programme on which the nation is now entering.

War, or the possibility of war, raises another consideration. Not only is manufacture on an extensive scale necessary, but supplies of certain materials far in excess of the normal are required. This requires foresight and the building up of stocks. In this aspect of affairs, this country has a good record, and September, 1939, did not find us short of adequate stocks of vital materials. Most of our necessary overseas supplies may be drawn from the Empire or the Americas, and our control of the seas enables us to continue to obtain what is necessary. The procedure, however, involves difficulty, danger and delay, and the pre-war stocks which were built up have certainly facilitated our passage through the first year of war without suffering any important shortage. The United States, despite its extent, and its mineral and agricultural wealth, is no more self-sufficient than are these islands. Portions of its supplies of antimony, chromium, manganese, mercury, mica, nickel, rubber, tin and tungsten have to be obtained from other countries, and as a precautionary measure the United States Treasury has appropriated ten million dollars for the purchase of stocks of materials which have either to be obtained entirely from abroad or the domestic supplies of which are insufficient.

In one aspect of this matter the United States has an advantage over this country. Its great natural wealth is such that there always exists the possibility that investigation may show minerals normally obtained from abroad actually to be available within its own borders. They may exist in a form which renders them commercially unworkable in normal times, but the incidence of war upsets many commercial considerations. A survey designed to discover what strategic materials, normally obtained from abroad, may actually be found within the borders of the United States has recently been carried out by the Bureau of Mines in conjunction with the Geological Survey. This has had some encouraging results. Not every class of material has shown any possibility of an increase in native supplies, and it does not appear that the figure of 0·2 per cent. for tin produced at home is likely to be improved on. As, however, the country draws its tin from British and Dutch sources, the cutting-off of supplies is unlikely. No important possible source of nickel was discovered, but, again, supplies are available from British sources. Metals of which sources of native supply have been discovered are antimony, chromium, tungsten, mercury and manganese. The ores are, in general, of sub-commercial grade, but are quite suitable for working in war-time. In the case of tungsten, particularly, it is stated that there is a good possibility that the United States may become self-sufficient. At the present time, 50 per cent. of the consumption is imported.

NOTES.

THE WAR IN THE AIR.

IT is now possible to supplement the figures of the enemy's losses in the air, which we published on page 133 of our issue of August 16. Since that date the war in the air has intensified many-fold, compared with the period which preceded it. It is gratifying, therefore, to record that the Royal Air Force has not only manfully withstood the strain, but has imposed much greater losses on the enemy than any it has received. It has inflicted damage which may well be irreparable on the enemy's factories, aerodromes, store houses and communications. Over 200 military targets have been struck, many on a number of occasions. According to official figures, since the beginning of the war the Germans have lost 3,644 machines, of which 1,109 were brought down in August and 1,102 in September. During the same period, the Royal Air Force lost 1,417 machines, of which 372 were brought down in August and 387 in September. During the first of these months, however, 148 pilots, and during the second, 168 pilots, were saved. Of the 1,102 aircraft lost by the Germans in September, 459 were bombers and 516 fighters. All except nine were brought down over Britain or British waters. The Royal Air Force were responsible for 960, anti-aircraft guns for 130, and the balloon barrages for three. Even these figures of absolute and relative success do not tell the whole story. It is probable that the enemy losses should be increased by some 20 per cent. to cover machines which were so badly damaged that they would require replacement, even if they reached their bases. This would bring the total up to 4,372. A further addition must also be made, for, during the fighting in May, in the Low Countries and France, the French, Belgian and Dutch are credited with having brought down 1,075 machines, increasing the German losses to 5,447; while still more planes, the number of which is uncertain, must have been destroyed during the Polish and Norwegian campaigns. Assuming a grand total of 6,500 to cover all losses, it may further be assumed that more than half of these were bombers and that the total personnel lost, therefore, is not less than 13,500. The question arises, how far these losses in both men and material have been and can be replaced, and, supposing that replacement is theoretically possible, how far it has been slowed down by the continuous British night attacks on enemy oil depots and refineries, armament works, aerodromes, docks and naval bases, goods yards and railway junctions, and barges and shipping. That the British losses have been more than replaced is certain, and it is equally certain that, with the assistance of the United States, superiority in numbers will shortly be achieved. When that time comes, the problem will be to decide how policy, strategy and tactics should be modified to suit the new conditions. From more than one point of view, this decision will not be easy.

THE POWERS OF THE CENTRAL ELECTRICITY BOARD.

The Central Electricity Board has been given powers under the Emergency Powers (Defence) Order to generate electricity themselves and to provide and operate generating stations. It may be recalled that under the Electricity (Supply) Act, 1926, the owner of a selected station who fails to carry out the directions of the Board regarding its operation or extension may be deprived of his ownership. The station may then be acquired by some other authorised undertaking, company or person, or, as a last resort, by the Board. Similarly, although primarily the Board are required to make arrangements with existing undertakings for the provision of new stations, they can, failing such arrangements, be authorised by the Electricity Commissioners to build the station themselves. In effect, these powers have not been exercised, as there has been eagerness rather than reluctance to provide the additional capacity required. The new position is apparently that the Board can now build their own stations irrespective of the selected-station owners, provided that the Electricity Commissioners consent, but must still try to arrange with the other undertakers to operate them on reasonable terms before proceeding to do so themselves. This modification is probably linked up with the announcement which we reported last week, that new stations are to be built in South-East England, South-West England and South Wales, respectively. These stations are not to be of very large capacity, and their output may be required under war conditions in some area, the electrical development of which has not yet reached a high standard. When war ceases, therefore, they might become redundant by reason of position, and it may be felt that it would be unfair, on this account, to saddle an existing undertaking with them. There has been some criticism of the arrangement in our electrical contemporaries, but war justifies many worse things than this, and there seems no very sound reason why existing undertakings should be perturbed.

THE AMERICAN DESTROYERS.

In our issue of September 20, we recorded the names of the first eight of the fifty destroyers which have been transferred from the United States Navy to the British flag. It will be recalled that the names selected were Churchill, Caldwell, Cameron, Castleton, Chelsea, Chesterfield, Clare and Campbeltown, all being the names of towns or villages common to the countries concerned in the transfer. The same principle has been observed, with certain territorial modifications, in naming the remaining 42 vessels, according to an Admiralty statement. Two ships, St. Albans and St. Mary's, will bear the names of towns which are found in Newfoundland as well as in the United Kingdom and the United States of America. Six ships will bear the names of towns in the West Indies, as well as in the United Kingdom and the United States of America, viz., Bath, Brighton, Charlestown, Georgetown, Hamilton and Roxborough. Twenty-eight ships are to be named after towns and villages common to the United Kingdom and the United States of America. Their names will be :—Belmont, Beverley, Bradford, Broadwater, Broadway, Burnham, Burwell, Buxton, Lancaster, Leamington, Leeds, Lewes, Lincoln, Ludlow, Mansfield, Montgomery, Newark, Newmarket, Newport, Ramsey, Reading, Richmond, Ripley, Rockingham, Salisbury, Sherwood, Stanley and Wells. The remaining six destroyers are being manned by the Royal Canadian Navy, and, as announced by the Canadian Government, will bear the names of towns and villages common to Canada and the United States of America. They will be named :—Annapolis, Columbia, Niagara, St. Clair, St. Croix and St. Francis.

ENGINEERS AND THE RECONSTRUCTED GOVERNMENT.

In time of war, Government reconstruction is probably of more interest to engineers than during peace, mainly because the actions of the members of the Cabinet and of the departments which they control exert a more direct pressure upon them. The changes which were announced on Friday last, are of particular interest, since it is the departments with which engineers are most closely connected which are principally involved. Sir John Anderson, who, with a great deal of success and in the face of much criticism, has wrestled for many months with the problems of protection against air raids and all that they involve in the sphere of engineering, becomes Lord President of the Council, where he will be titular head of the Department of Scientific and Industrial Research. In performing this part of his duties, he will have the assistance of the new Scientific Advisory Committee, presided over by Lord Hankey, the appointment of which is discussed in our leading article on page 291. Mr. Herbert Morrison leaves the Ministry of Supply to become Home Secretary and Minister of Home Security. In the former position, he has exhibited all those qualities of drive and farsightedness which made him a most successful Minister of Transport in the last Labour Government, and, no doubt, will continue to do so in his new post, where there are many problems relating to air-raid protection which still require solution. His place at the Ministry of Supply is taken by Sir Andrew Duncan, who has done good work at the Board of Trade since Mr. Winston Churchill became Prime Minister, and the vacancy thus created has been filled by the appointment of Captain Oliver Lyttleton, who is well known as managing director of the British Metal Corporation, Limited, and has latterly been Controller of Non-Ferrous Metals at the Ministry of Supply. Sir John Reith, after short terms at the Ministries of Information and Transport, becomes First Commissioner of Works and also Minister of Works and Buildings. The latter is a new department about which more information is promised later, though it may be hazarded that one of its principal duties will be to deal with difficulties produced by enemy action, both in London and elsewhere. Hardly less important will be the co-ordination of the 300,000,000*l.* building programme for war purposes, which is now being undertaken by various Government departments. Sir John, who is to be elevated to the House of Lords, is credited with a preference for new jobs and there can be no doubt that, in his latest post, there will be plenty of opportunity for the exercise of his powers of organisation and drive. Finally, Lieut.-Colonel J. T. C. Moore-Brabazon becomes Minister of Transport, an appointment which should receive the approval of those who believe that the future of transport is on the road and in the air. He was Parliamentary Secretary of the Ministry in 1923-24 and again from 1924 to 1927, and unlike the rest of the new promotions, is a Member of Parliament of long standing. He has the distinction of holding the Royal Aero Club's certificate No. 1.

DISTRIBUTION OF STEEL SUPPLIES.

In our issue of March 29, 1940, we called attention to a new system of rationing iron and steel which had been devised by the Iron and Steel Control, Ministry of Supply, to replace the previous system of issuing licences. In particular, the scheme was designed to provide adequate safeguards against the tendency of Government departments and other consumers to over-estimate their future requirements, and to enable the relative urgency of the needs of the several classes of users to be determined. Experience during the last six months, however, has shown that the scheme could be improved in certain details, especially in the direction of simplification, and a revised edition has now been issued with that object. The changes are not, however, fundamental; indeed, it is claimed that the scheme emerges from the trial period, accepted as the practical way of assuring that the best use is made of our steel supplies. Speaking generally, the scheme applies to all acquisitions of finished steel except those which are to be converted into other forms. For this purpose, all the consuming interests have been grouped under the Government and other authorities, who will each receive for delivery in each quarterly period a tonnage allocation of finished steel. With certain exceptions, no finished steel may be acquired unless the tonnage involved is authorised in writing by symbol, authorisation number and period numbers, or by licence issued under the Control of Iron and Steel Order. To prevent more steel being obtained than is actually required for any one contract, a reference number will be incorporated in the authorisation form. Steel which is not required for Government contracts must be applied for to the appropriate Government department. The needs of the home civilian trade will be met by licences authorising the purchase of finished steel issued by the Iron and Steel Control, which will also issue licences for direct exporting trade and stockholding merchants. Stocks cannot be replenished without a licence.

RAILWAY COLOUR-LIGHT SIGNALS.—The Ministry of Transport states that the beam emitted by railway colour-light signals is quite invisible from a normal flying height and is consequently of no assistance to enemy aircraft. All such signals, on erection, are carefully adjusted so as to be in exact alignment with the engine-driver's vision. A committee composed of representatives of the Air Ministry, the Ministry of Transport and the Home Office, which investigated the problem in 1938, reported that, provided the signal lights were equipped with 2-ft. hoods, no material assistance would be given to enemy aircraft at normal flying heights. Such hoods, it is stated, have been fitted to all these signals.

MARKETS IN CENTRAL AMERICA.

In preceding articles which have appeared in Engineering dealing with British trade prospects in the principal South American markets, emphasis has been laid upon the fact that, with the disappearance of Latin-American trade with Germany, it is in the best interests of both the United States and Great Britain to assist in solving the problem presented by Latin-America's ever-mounting surpluses of primary products and the consequent reduction in purchasing power. This can obviously best be done by means of reciprocal trading arrangements, so as to enable Latin America to remain independent of trade with the totalitarian Powers. On its part, the United States Government has speedily approved the increase of the capital of the Export-Import Bank of Washington to 500 million dollars, such increased capital to be utilised to finance North American trade with Latin America. The war period has already witnessed a considerable growth in exports (particularly in engineering goods, railway materials, etc.) to South America from the United States, the latter being obviously assisted by geographical proximity and freedom from the transport and other war-time difficulties which beset Great Britain.

So far as concerns Great Britain, the Government here is taking commendable steps to support the trade drive in South America, being fully aware of the necessity to extend British markets there, in order to replace those lost on the continent of Europe. Britain alone cannot deal with so vast a problem as South America's large surpluses of products, but it is hoped that joint action with the United States may eventually result in at least a partial solution to the problem. Meanwhile, the South American Republics, as well as Britain, are showing remarkable patience and sympathy with each others' economic problems, and a strong desire is expressed on all sides to ease the burden which the war has placed on the economy of all the parties concerned.

The steps recently taken by the British Government to support the trade drive in South America are of an important and comprehensive nature. Firstly, the Government has decided, with the approval of the other Governments concerned, to send a special trade mission to South America under the leadership of Lord Willingdon, who will be accompanied by representatives of important industrial and export interests, associated principally with rubber, leather, pottery, cotton, coal, wool, textile machinery, paint, electrical goods, and constructional industries. The mission will leave in mid-October, will visit the principal South American countries, and will reply to German propaganda by showing that Britain can deliver all kinds of goods. Arrangements are being made for an exhibition of British goods in the principal cities.

A further important step is the decision to enlarge both the capital and scope of operations of the officially-sponsored United Kingdom Commercial Corporation, representatives of which are proceeding to Argentina with the object of setting up an organisation to facilitate the important trade between the United Kingdom and South America. To supplement the normal deliveries of British goods to South American markets, the President of the Board of Trade, acting on the recommendation of the Export Council, has authorised the Corporation to take the necessary steps to facilitate the holding in South America of adequate stocks of those United Kingdom goods which South America requires. As rapidly as conditions permit, the United Kingdom Commercial Corporation will endeavour to create in other South American countries organisations similar to that set up in Argentina. The Corporation will not itself trade, but will use existing trade channels and help in opening up new ones.

In addition to the active British trade propaganda in South America adumbrated by the visits of the missions mentioned, British trade should be buttressed by the extended insurance scheme of the Export Credit Guarantee Department, as well as by the conclusion of sterling Clearing Agreements with the principal South American countries. Following upon the recent conclusion of such agreements by Britain with both Argentina and Brazil, agreements were also signed with both Uruguay and Peru in September. All these agreements are on similar lines, eliminating free sterling and canalising payments in official sterling between the countries concerned and Great Britain by means of special accounts opened with authorised banks in this country. An outstanding feature of the agreements is that they tend towards trade reciprocity; that is to say, they ensure exchange cover at agreed rates to pay for imports of British goods to the extent that Britain purchases products from the country which is the other party to the agreement.

All the foregoing factors are well designed to support British trade in South America on reciprocal lines in the present difficult circumstances. At the same time, it is as well to emphasise that its maintenance will depend fundamentally upon British prices being fully competitive and delivery contracts free from those irritating qualifications which, since the war started, have frequently led to South American orders being diverted from Britain to the United States. The solution of price and delivery difficulties mainly lies, of course, with the Governmental authorities responsible for the supply of raw materials to the manufacturing and exporting branches of British industry. It cannot be too strongly emphasised that, as in the Great War, the difficulties of obtaining or paying for imported goods will undoubtedly give a decided fillip to the ever-growing national manufacturing industries of South America, which may permanently affect the import demand for many lines of articles.

The Latin-American countries with which it is proposed to deal in this article comprise those falling within the "coffee" group of Central America. They comprise the small States situated in Central America proper (*i.e.*, Guatemala, Nicaragua and El Salvador), as well as Ecuador, and—by far the two most important—Colombia and Venezuela, which actually form part of the northern mass of the South American sub-continent. The Central American republics of Guatemala, Nicaragua and El Salvador are dependent almost entirely upon the production of coffee. In normal times, they easily disposed of their coffee crops, which are of the favourite "mild" variety, and were not faced with Brazil's chronic problem of over-production. In fact, the steps taken by Brazil for many years to support the price of coffee artificially were of direct benefit to the Central American countries. Developments since the outbreak of the European War, however, have altered the complexion of affairs, inasmuch as the important markets for coffee in Germany and elsewhere in Europe have been cut off by the British blockade, so that the United States is practically the only remaining market for coffee produced in the Western Hemisphere. The United States is in a position, therefore, to dictate prices for both Central American and Brazilian coffees, and to increase the already preponderating North American influence in these coffee-growing countries. This influence is strengthened by the very efficient air-transport lines which run from North America down through Central America to the principal States of South America. Further, American financiers and engineers preponderate in the development of Central America, such as in the active building of the Pan-American Highway and on other public works. Incidentally, Ecuador is dependent more upon cocoa than coffee, and the present outlook is obscure by reason of conditions in the international cocoa market.

Of the two more important countries of Venezuela and Colombia, the latter has an estimated area of some 462,000 sq. miles. The chief features of the country's topography are the three parallel ranges of the Andes mountains running north to south, and the districts of greatest fertility and commercial importance are often the most remote and difficult of access; however, the country is very rich in farming and mineral resources, which give rise to optimism regarding the country's future development. The official census in 1938 gave a total population of nearly 9,000,000 persons, a figure which is only exceeded in South America by those of Argentina and Brazil.

The growth in the oversea trade of Colombia is amply demonstrated in Table I, herewith. In connection with this table, it must be emphasised

Table I.—*Colombia': Imports and Exports.*

Year.	Imports.	Value in Colombian Pesos.	
		Exports.	Trade Balance.
1923	67,208,000	56,004,000	−11,204,000
1928	162,381,000	132,502,000	−29,879,000
1932	34,327,000	67,109,000	+32,782,000
1935	119,677,000	123,602,000	+ 3,925,000
1936	134,441,000	136,844,000	+ 2,403,000
1937	160,682,000	152,169,000	−17,513,000
1938	159,259,000	144,446,000	−14,813,000
1939	183,461,000	136,471,000	−46,990,000

that, in order to arrive at the effective balance of trade, it is customary to deduct from the total value of exports that proportion of the proceeds of certain products shipped abroad which is not available to pay for imports, namely, petroleum, 100 per cent.; bananas, 30 per cent.; and platinum, 32 per cent. Moreover, it should be noted that the export totals do not include the values of gold shipments. During the period of uneasiness which preceded the present war, there was a great increase in the laying in of stores from abroad. Before the war, among European countries, Germany had the greatest volume of trade with Colombia, closely followed by Great Britain as a seller and France as a buyer. The bulk of Colombian foreign trade, however, was with the United States and Canada. The statistics given in Table II, below, show

Table II.—*Principal Exports from Colombia for the Year* 1938.

Exports.	Volume.	Value in Colombian Pesos.
Coffee (60 kilos per sack)	4,229,000 sacks	88,775,000
Petroleum	2,651,000 metric tons	37,206,000
Bananas	7,493,000 bunches	8,884,000
Ox Hides	7,000 metric tons	3,876,000
Platinum	914 kilos	1,651,000
Tobacco leaf ..	5,000 metric tons	1,027,000

the very great dependence of Colombia upon the coffee export trade. In this connection, the disappearance of the important European coffee markets have led to difficult times in Colombia, which is, therefore, becoming more and more dependent upon North American markets. Negotiations for a new commercial treaty with Britain have not so far come to a successful conclusion, in spite of the various suggestions which have been considered. It is to be hoped, however, that an agreement can be reached, since, at present, this would undoubtedly help to strengthen the bonds of sympathy, besides facilitating trade, between the two countries.

The year 1938 is the latest complete period for which statistics of imports of engineering goods are available, and these are given in Table III, below.

Table III.—*Colombia: Imports of Engineering Products in* 1938 *from the Principal Supplying Countries.*

Imports.	Value in Pesos.		
	United States.	United Kingdom.	Germany.
Transport material ..	10,384,000	93,000	810,000
Tractors for agricultural purposes	1,980,000	8,000	9,000
Textile machinery ..	1,423,000	560,000	302,000
Boring machinery (petroleum)	601,000	40,000	100
Refining machinery (petroleum)	1,008,000	300	—
Petrol and Diesel engines and spares	945,000	103,000	272,000
Electric generators, transformers and motors ..	842,000	64,000	190,000
Dredgers of all classes ..	533,000	—	81,000
Steam boilers	244,000	3,000	6,000

These serve amply to demonstrate the preponderance of North American sales in the Colombian markets. This close relationship is being fostered by the present United States Government, and a recent

loan for 10,000,000 dols. by the Export-Import Bank of Washington to the Colombian Government is facilitating mutual trade.

The feeling is widely expressed in South American circles, however, that they would prefer to sell their goods to North America and the British Empire, rather than receive loans which might pave the way to political influence. To meet the crisis, the Colombian Government, on June 18, issued a complete economic plan. It includes a number of measures connected with public finance and assistance for agriculture, stock breeding and industry. Among important parts of the plan is that of public works, which will include new railways, the completion of the main line in the west, the completion of the harbour of Tumaco, and the main roads in the east and west, which are to connect the network of roads in the centre and south with the network on the Atlantic Coast. The construction of the Colombian section of the Great Pan-American Road, which is to run through the whole continent, will be another great achievement. The plan, with its object of a more rational and complete exploitation of Colombian products, has met with a very favourable reception. It has already stimulated confidence, and the benefits will increase as it comes fully into operation. The variety of the country's valuable products—gold, silver, coffee, oil, and bananas—provides a sound basis for development, and, coupled with the political stability of a democratic government, gives grounds for looking into the future with confidence.

Venezuela is bounded on the west by Colombia, and has an area of about 394,000 sq. miles, or about twice that of Germany. The population is about 3,500,000. The agricultural resources include coffee, sugar, cocoa, cotton and tobacco, while approximately one-third of the area of the country—the *Llanos*, watered by the Orinoco and its tributaries—is good for stock-raising, although the lack of transport has prevented the industry from developing. Forests extend over nearly half the republic, and their resources have been barely tapped. With regard to mineral wealth, Venezuela is now the third largest oil-producing country in the world, the oilfields covering some 27,000 sq. miles and having been rapidly developed. The basin of Lake Maracaibo has proved the most prolific South American source of oil and one of the chief producing areas in the world. The country also yields gold, coal, copper and magnesite. Table IV, herewith, compares the values of Venezuelan

TABLE IV.—*Venezuela : Imports and Exports.*

Year.	Values in Bolivares.		
	Imports.	Exports.	Trade Balance.
1917	118,684,000	119,988,000	+ 1,304,000
1920	315,173,000	170,644,000	−144,529,000
1921	95,508,000	133,560,000	+ 38,052,000
1929	452,852,000	778,560,000	+325,708,000
1935	225,194,000	711,730,000	+486,536,000
1936	211,590,000	768,463,000	+556,873,000
1937	304,634,000	871,463,000	+566,829,000
1938	310,949,000	887,276,000	+576,327,000
1939	324,752,000	953,337,000	+628,585,000

imports and exports over a number of recent years. Here, again, however, as in the case of Colombia, the balance of trade shown is more apparent than real, in view of the fact that exports consist largely of petroleum, the proceeds of which do not return to the country in full. It is for this reason that coffee plays a very large part in the economic position of Venezuela notwithstanding that, as will be seen from Table V, on this page, exports of coffee are, in fact, very much lower in value than those of petroleum and derivatives.

So far as concerns imports, both Colombia and Venezuela are mainly dependent upon foreign supplies, the industrial development being unimportant, especially in the heavy industries. The details given in Table VI, on this page, of imports of engineering products into Venezuela during the year 1937, show the preponderance of imports from the United States, which is not surprising in view of the large amount of North American capital invested in the Venezuelan oilfields.

As pointed out in previous articles dealing with Latin American markets, British manufacturers who are not familiar with trading conditions in Central America, and who may wish to take the opportunity of extending their markets, should be able to secure assistance from the Export Council through their appropriate Group, particularly in regard to the formalities introduced by the Defence Regulations in this country. However, it may be remarked that the usual, and probably most satisfactory, method of opening up business in the countries of northern South America and Central America is by the personal visit of a representative who speaks Spanish, which is the national language of all these countries. Moreover, the competitive nature of these markets demands that correspondence, catalogues, etc., be drawn up in Spanish,

TABLE V.—*Principal Exports from Venezuela in* 1937.

	Volume in Metric Tons.	Value in Bolivares.
Petroleum and derivatives	25,971,000	770,042,000
Coffee	42,000	38,091,000
Cocoa	16,000	13,942,000
Livestock	13,000	2,806,000
Hides	3,900	4,371,000
Vegetables, fruit, etc. ..	6,900	1,063,000
Other vegetable products	3,100	635,000
Gold bullion	—	15,315,000
Gold (coined)	—	20,800,000

while, as the metric system is employed throughout Latin America, the use of British measures should be avoided in quotations and estimates.

The best route for a representative to follow in visiting Central America is via New York, whence the respective countries can be reached easily by air-line, or, alternatively, by the steamships of the Grace Line or the United Fruit Company. In Colombia, the customary and most convenient connection from the United States with Bogotá and intermediate points is by air. Before leaving Great Britain, the commercial visitor to the various countries should visit their respective consulates in Britain, in order to comply with passport regulations and to obtain conditions as to licences, samples, etc. Valuable information upon conditions in Colombia can be obtained from the Anglo-Colombian Chamber of Commerce, 12, Cadogan-place, London, S.W.1; and reports on marketing conditions, agencies, etc., are also available at the Bank of London and South America, Limited,

TABLE VI.—*Venezuela : Imports of Engineering Products in* 1937 *from the Principal Supplying Countries.*

	Value in Bolivares.		
	United States.	United Kingdom and Colonies.	Germany.
Road transport material and accessories ..	21,824,000	462,000	504,000
Railway material ..	49,000	5,000	300
Marine transport	478,000	2,000	109,000
Sewing machines	1,178,000	10,000	170,000
Copper, bronze and brass and manufactures	555,000	143,000	706,000
Iron and steel and manufactures	3,713,000	628,000	5,886,000
Hydraulic pumps ..	212,000	3,000	40,000

6, Tokenhouse-yard, London, E.C.2, which has branches throughout the various republics; as well as at the British and Latin American Chamber of Commerce, 11A, Union-court, London, E.C.2.

With regard to the financing of exports to the countries concerned, a large proportion of trade is conducted by means of documentary bills sent through a bank for collection. In this connection, some comment is necessary upon the foreign exchange position. All the exchanges of the various countries are based upon the United States dollar, and the approximate sterling rates may be obtained by applying the dollar-sterling exchange rate. The following comparison gives the latest position :—

Colombia :*
Sight selling rate on New York was 175.50 pesos per 100 U.S. dols. on September 3. This rate applies to holders of exhange permits buying in the open market.

Venezuela :
Sight selling rate on New York has been maintained at 3.19 bolivares per U.S. dol. since April 27, 1937.

Guatemala :
Sight selling rate on New York is maintained at one quetzal per U.S. dol., but a commission of 1 per cent. is charged by the Central Bank for the sale of drafts.

*Nicaragua :**
Sight selling rate on New York, for payment of imports, was fixed by the National Bank at 5.52½ cordobas per U.S. dol. (including 10 per cent. tax and ½ per cent. commission) on June 9, 1938.

El Salvador :
Sight selling rate on New York was 2.50⅞ colones per U.S. dollar on August 31.

*Ecuador :**
Sight selling rate on New York was 16.90 sucres per U.S. dol. on August 16.

* Exchange controls are operative in these countries.

In Colombia, the coffee position during recent months has resulted in exchange stringency. Imports are classified in four groups, the first category being essential imports, and the other three groups for imports of other goods. At present, exchange cover is forthcoming for imports in all four groups into Colombia of goods of United States and Canadian origin through funds provided by the recent credit of 10,000,000 United States dols. granted to Colombia by the Export-Import Bank of Washington. With regard to imports from Great Britain, exchange is now usually only forthcoming for those in Group No. 1, although this group includes most engineering goods, such as iron and steel; tools and precision instruments; agricultural implements; textile machinery; electric accumulators, dynamos, motors, transformers, etc.; rubber tyres; omnibus and motor-lorry chassis; motor tractors; and machinery oil. Private automobiles, however, are included in Group No. 2 if costing less than 1,000 United States dols c.i.f., and in Group No. 3 if costing more than that figure.

With regard to bills for collection covering exports to Venezuela, during the past year the supply of foreign exchange in that republic has been insufficient to meet in full the requirements of importers and other purchasers. This shortage has been due mainly to the abnormal increase in imports since the war commenced. It is believed that the volume of imports is now declining, but there are indications of a reduction in exports of petroleum products, which are the principal source of foreign-exchange supplies in this country. For some time past measures have been taken by the Government to concentrate in the National Exchange Centralisation Office all foreign currency derived from exports, and that office provides each bank with a weekly quota of exchange which is resold by the bank almost entirely in cover of commercial requirements, sales for private purposes being strictly limited. These weekly quotas have been maintained regularly by the Centralisation Office throughout the year, and occasional additional supplies have also been forthcoming from that source. Nevertheless, the shortage of exchange has become increasingly acute during the past few months, and, as a result, most banks in Venezuela now have a large number of bills which they are unable to collect promptly, although the drawees wish to pay. Bills are collected, therefore, in strict rotation, according to the date when the drawee tenders payment, but, unless the supply of exchange increases, it is likely that for some time to come the delay in effecting remittances will increase gradually.

IMPORT DUTIES ON TWIST DRILLS.—The Treasury has issued an Order, entitled the Additional Import Duties (No. 8) Order, 1940, which simplifies the duties chargeable on twist drills. The Order, S.R. & O., 1940, No. 1694, price 1*d.*, came into operation on October 1.

FORMATION OF FUEL-OIL BURNER EXPORT GROUP.—Member firms of the British Oil Burner Manufacturers' Association, who specialise in the manufacture and application of oil-burning equipment, have formed the Fuel-Oil Burner Export Group, under the export scheme fostered by the Board of Trade. Mr. W. A. Hubbard, of Messrs. Combustions, Limited, is chairman, and Mr. Stanley Henderson is secretary. The Group's offices are at 69, Cannon-street, London, E.C.4. Arrangements have been made to give special attention to the requirements of markets in the Dominions, Palestine, Egypt, Irak, Iran, Portugal, the Dutch East Indies and the Far East.

LETTER TO THE EDITOR.

SPECIFIC SPEED OF PUMPS AND TURBINES.

To the Editor of Engineering.

Sir,—Mr. J. R. Finniecome's contribution to this discussion was very valuable, as showing how specific speed is related to the various dimensions and reference velocities within the machine. All these formulæ exhibit the truly non-dimensional character of specific speed. The paragraph in my letter in your issue of August 16, page 137, stating that "specific speed cannot be regarded as a speed at all, but only as a dimensionless parameter," has been criticised both by Mr. Guppy and, in private correspondence, Mr. Finniecome's formulæ provide corroboration of this statement.

While the efforts of Mr. Guppy to provide a physical interpretation are appreciated, one wonders whether the conception of specific speed as the rotational speed of a hypothetical machine will produce any useful mental picture. It seems to the writer that there is something unsatisfactory in the usual text-book definition as quoted by Mr. Guppy, although it cannot be denied that a mathematical expression may be deduced therefrom. The reason for this is that it appears illogical to define a characteristic of one machine by the introduction of another hypothetical machine. The argument that specific speed is a rotational speed depends entirely on this hypothetical machine. If this machine is jettisoned, then the argument collapses. The writer suggests the following as giving a truer idea of the nature of specific speed. "Specific speed is a special criterion, calculated from the operating conditions of a turbo-machine, which remains practically constant for similar dynamical states over a range of speeds and sizes of a series of geometrically similar machines."

Similar dynamical states would mean similar flow patterns throughout the machine, therefore, similar energy changes and constant efficiency. There are a large number of criteria having the above property, but the particular one known as specific speed is arranged so as to contain the first power of the rotational speed in the numerator, and not to contain a linear dimension of the runner. The fact that specific speed is only approximately constant for similar dynamic states was discussed in previous letters by Dr. McDonald and the present writer.

Yours faithfully,

J. Jennings, B.Sc., A.M.I.Mech.E.

Aston Technical College,
Birmingham, 6.
October 3, 1940.

PROBLEMS OF POROSITY IN ALUMINIUM-ALLOY CASTINGS.

Although light-alloy castings show some tendency to porosity troubles, they are by no means unique in this respect, some heavy-metal alloys being still more prone to difficulties from this cause. Nevertheless, the characteristic chemical, physical and mechanical properties of aluminium alloys, in general, have a distinct influence on the degree and type of porosity and analogous defects which may occur in these materials when they are cast. Thus, the low specific gravity of the alloys offers little resistance to the entry of mould gases—including air and steam—into the melt. Furthermore, aluminium alloys melt at relatively low temperatures, which are in marked contrast with the high melting point of the oxide of the metal, particles of which, if entrapped, show no tendency to escape to the surface of the melt, owing to the fact that their specific gravity is similar to that of the metal itself. Moreover, many of the alloys are hot short at temperatures just below the freezing temperature and some exhibit high shrinkage on solidification, thus further adding to the problems which the founder is called upon to solve. During the past five or ten years, however, much progress has been made and, although a complete solution to porosity troubles has not been found, the intensive research which is being carried out is making itself felt by distinct improvements, not only in the inherent high strength of many castings but in the uniformity of quality in mass production. It is stated in a publication entitled "Porosity and Analogous Problems in Aluminium-Alloy Castings," recently issued by Aluminium Union Limited, The Adelphi, Strand, London, W.C.2, that even on comparatively small outputs of ordinary work, wasters have been reduced to a fairly common level of 5 per cent., while, on large and long-continued outputs of a given casting, a figure as low as 0·75 per cent. is sometimes claimed to have been arrived at. In the case of castings which have to pass severe tests for pressure tightness, on the other hand, wasters may average from 10 per cent. to 15 per cent.

No suggestions of a striking character for the removal of gases from melts of aluminium alloys are made in the publication, but great emphasis is laid on the supreme importance of the strict observance of a number of well-defined routine precautions and of making reasoned modifications in established principles to cater for the specific requirements of particular alloys and particular designs. Brief mention is made of the practice of pre-solidification and of the use of chlorine or of certain volatile inorganic halogen salts, for the de-gassing of some melts, but it is indicated that these methods are more in the nature of expedients applicable in special cases, and that their adoption has not found general acceptance. The author obviously believes that prevention is better than cure and rightly shows a distinct preference for those methods which aim at keeping the melt free from possible contamination by gases and impurities. He advocates the careful scrutiny of the metal to be melted down. The shrinkage cavity of virgin-metal ingots should be examined for traces of grease, carbonaceous dust or moisture accumulated during transport or storage, while scrap must be carefully examined to determine whether it is free from excessive oxidation due to bad storage and particularly whether it is free from such foreign substances as cutting compounds. These, of course, might lead to the introduction of steam into the melt; steam is decomposed in the presence of molten aluminium, the liberated hydrogen being absorbed and causing porosity in the final casting.

Careful attention, the author continues, should be paid to melting procedure and it is urged that for furnaces other than those of the electric type, that is oil-fired or coke-fired furnaces, the design must be such that contamination of the charge by products of combustion is rendered virtually impossible. Moreover, when putting a furnace into operation, adequate precautions should be taken to ascertain that the refractories and the crucible have been rendered quite free from moisture. When melting down metal for sand or gravity die-casting, three factors must be carefully borne in mind. In the first place, the charge should be melted down at a reasonably rapid rate to avoid undue exposure to possible contamination. Secondly, the metal should be heated only to that temperature, above its melting point, which experience has shown to be essential in order to attain ideal pouring conditions for the prevailing section of the casting, or for the particular size of casting under production. Finally, the melt, having been brought up to the desired temperature, should not be allowed to "stew" for any period longer than necessary. Pyrometric control must be maintained at every stage of the process, and bare-wire thermocouples of the immersion type are recommended.

For sand castings, the author states that fine sands are to be preferred, as they impart a better finish to the product than do coarse sands. Owing, however, to the low gas-displacing powers of light alloys, due, as previously mentioned, to their low specific gravity, great care should be taken that the sand moulds are not too heavily rammed, otherwise a potential source of blowholes is created. The use of unyielding cores in the case of certain intricate castings may result in hot tearing or cracking, owing to the greater or lesser degree of hot shortness associated with most aluminium alloys. Further, gating requires careful attention in order that turbulence may be avoided; otherwise dross inclusions are likely to be formed in the casting. Gravity die castings introduce fewer porosity difficulties than do sand castings, but special attention must be paid to the design of the die and the cores as, being composed of perfectly rigid material, cracking of the casting is liable to occur unless shrinkage stresses are adequately compensated for by the use of chills and by carefully designed and located gates.

Liverpool Engineering Society.—The Council of the Liverpool Engineering Society has decided not to hold evening meetings for the present. The matter, however, will be reconsidered early in the New Year. Meanwhile, the papers which appeared in the provisional syllabus will be printed in the *Bulletin* and it is hoped that members will contribute to written discussions on these papers.

Rail-Defect Detecting Car: Erratum.—An unfortunate displacement of three illustrations on Plate XVI, of September 20, relative to the Sperry rail-defect detecting car, should be corrected. The illustrations involved are Figs. 8, 9 and 10. The captions following the figure numbers agree with the references to these numbers in the text, but the illustration above Fig. 10 should have been placed above Fig. 8, while those above Figs. 8 and 9 should have appeared above Figs. 9 and 10, respectively.

PROGRESS OF HIGHER PRESSURES IN INDUSTRIAL PLANT.*

By William F. Ryan.

The first American Society of Mechanical Engineers' paper on the value of higher steam pressures in industrial plant was presented at the annual meeting in 1925. From a present-day point of view, there were no high-pressure industrial power plants at that time. Published records disclose only eight installations, with a total capacity of 13,425 kW, then operating at pressures above 275 lb. per square inch,† and the highest pressure was 350 lb. One manufacturer had installed a small 1,250-lb. boiler for test purposes, four central stations were operating at a throttle pressure of 550 lb., and one designed for 1,200 lb. operating pressure was just being placed in service. Several 400-lb. and 450-lb. industrial plants were being considered, and at least five in that pressure range were in process of design or construction, but higher pressures, 500 lb. and upwards were still a subject of academic discussion so far as industrial applications were concerned.

"High pressure" is a relative term and for the purpose of this paper it is defined as not less than 500 lb. per square inch at the prime-mover throttle. Under this definition, the first high-pressure industrial power plant went into operation in 1927, although another manufacturer had installed a 1,250-lb. boiler for purely process work in 1926. No high-pressure industrial plants were reported in 1928, and not more than 12 were in operation at the end of 1933. Later development has been more rapid, but published records and other sources of information disclose only 85 plants now operating in the United States supplying power and steam to industries, in which the throttle pressure is 500 lb. or higher. This number includes six installations owned and operated by public utilities. The data on which this survey is based are drawn from these 85 plants and while no claim is made for completeness, it is believed that practically all of the major installations are included. The 85 plants have a combined power generating capacity of 1,166,875 kW and a total steam generating capacity of 30,785,300 lb. per hour. A number of additional plants are now under construction and it is expected that by the end of this year there will be nearly 100 plants in operation with a combined capacity of approximately 1,350,000 kW. These totals do not include the plants, at least 40 in number, where high-pressure boilers are installed to supply steam for process use only, for testing equipment, or for future power generation.

The foregoing figures include the River Rouge power plant of the Ford Motor Company, which contains one 15,000-kW back-pressure turbine-generator supplying steam to the manufacturing plant, and three 110,000-kW high-pressure condensing units which differ in no way from typical central-station machines. In subsequent analyses, these three condensing units are excluded from the totals in order to prevent distortion of the averages. On this basis, the combined capacity of the 85 plants is 836,875 kW, of which 284,000 kW is operated by public utilities and 552,875 kW by manufacturing concerns.

Pressures.—Excluding the condensing units at River Rouge, the 85 plants contain 134 turbine-generators and two reciprocating-engine generators. Of the 136 prime movers, 108 operate at throttle pressures between 500 lb. and 750 lb., but more than 25 per cent. of the installed capacity operates at pressures above 1,200 lb. There is no "trend" of pressure with respect to time. The highest pressure installation included in this group started operation in 1939, but the only other plant operating at a pressure above 1,600 lb. dates from 1931. The majority of plants in the 1,200 lb. to 1,600 lb. class have been completed since 1935, and five of the ten plants in this pressure range are operated by public utilities. Pressure is not a function of ownership, however, because the largest utility plant in the group operates at a throttle pressure of only 600 lb., and the two highest pressure plants, just mentioned, are owned and operated by manufacturing concerns.

No generalisations can be made about the "best" or the "ideal" pressure for plants supplying industrial steam. For condensing turbines in utility plants, it may well be argued that, in localities affording moderately priced fuel and abundant circulating water, there is no profit in throttle pressures above 900 lb. In the industrial plant, however, it may be economical to use the highest pressures commercially available if the electric power demand is high in proportion to the steam required for process work, and if load factor and other conditions are favourable.

In many industrial designs, the question of pressure has been approached from the wrong angle. In order to generate more by-product power in a given situation,

* Paper read at the Spring Meeting of the American Society of Mechanical Engineers, at Worcester, Mass., May 1-3, 1940. Abridged.

† All pressures are gauge unless otherwise stated.

process pressures have been limited or even reduced when greater overall savings might have been made by exactly the opposite procedure. In some heat applications, particularly evaporative processes, high saturated-steam temperature is quite as valuable as it is for power generation. One instance is recorded where changing the process pressure from 10 lb. to 150 lb. reduced the steam consumption approximately 50 per cent. This, of course, was a blow to by-product power generation in that plant, since the prime movers must operate on half the throttle flow and exhaust against a 500 per cent. increase in the absolute back pressure. The same quantity of by-product power could not be generated under the new conditions, even with a throttle pressure of 3,000 lb., but the fuel savings from reduced steam consumption were of such magnitude that a large net saving in production expense would remain if all of the power were purchased or generated by condensing units.

The use of high pressures for process work is a field in which some industries may make savings greater than any that are conceivable in connection with power generation. For the ultimate development of high pressures in industrial work, steam utilisation and power generation must be treated as a joint problem, the object being to secure the lowest overall manufacturing costs, rather than the lowest cost or highest yield of electric power.

Temperature.—More than half of the units, having 42 per cent. of the total capacity, operate at temperatures below 750 deg. F. In 1925, 750 deg. F. was generally accepted as the maximum practical temperature and in a paper written at that time the author made the perhaps naive statement that in considering how high a pressure should be used for non-condensing prime movers "it is almost axiomatic that the operating temperature should be as high as the materials of construction permit." Apparently it has seemed axiomatic to few others, and, in general, the tendency has been to use the lowest temperature that would give the required quality of exhaust steam. Nevertheless, the author believes that the problem of temperature in industrial power applications has not been correctly approached in many cases, and that some of the existing installations might have achieved equal results at less cost by using lower pressure and higher temperature.

The effect of throttle temperature on the water rate of back-pressure turbines is sufficiently well understood. For example, with 100 lb. back pressure, as much by-product power per unit of process steam can be generated with 550 lb. and 750 deg. F. at the throttle as with 700 lb. and 675 deg. F. The lower-pressure, higher-temperature steam, however, has a higher enthalpy, and it has been incorrectly assumed that a plant designed for those conditions would necessarily consume more fuel per unit of output. Also, the exhaust from the prime mover would be highly superheated and in many processes superheat is of no value. However, if a thoroughfare desuperheating heater is installed in the exhaust to remove the surplus superheat and transmit it to the boiler feed water, the fuel consumption for the two steam conditions would be identical, but the lower-pressure installation should show an appreciably lower capital cost, and slightly lower expense for auxiliary power, maintenance, and perhaps for feed-water treatment.

The analysis of this problem is one which justifies a paper in itself, and no attempt will be made to reach conclusions here, but the point to be emphasised is that the selection of steam temperature for the industrial plant is a problem peculiar to that type of power generation, and central-station practice has no more significance with respect to temperature than it has with respect to pressure. In designing an industrial power plant, temperature is not a secondary problem to be considered after the pressure has been determined, but a primary problem which may have a major effect on overall results. Temperature and pressure should be worked out together with full consideration of the effects of each on investment and operating costs.

Reheat.—All of the high-pressure utility plants operating or under construction in 1925 provided reheating of steam at some stage of expansion through the prime movers, using secondary superheaters located in the gas stream of one or more of the main boilers. So far as the author is aware, this practice has never been followed in an American industrial plant, but steam reheating has been used for two installations; these are the first 1,200-lb. unit at River Rouge, which is not included in this survey, and the reciprocating-engine installation at Lockland, Ohio. In the latter, steam is supplied to the throttles at 1,650 lb. and 810 deg. F., and passes through a live-steam reheater between the intermediate- and low-pressure cylinders. Originally, automatic regulation was provided, designed to maintain about 10 deg. F. superheat in the final exhaust from the engines. The reason for this arrangement has never been disclosed by the German designers, but thermodynamic analysis shows that an effective separator at this point would have given a better plant economy than the reheater. In present operation, the reheat is used only to the extent necessary to prevent pounding in the low-pressure cylinder.

Many industrial plants could make efficient use of the highest practicable throttle temperatures, but few, if any, could show a gain from reheating which would be commensurate with the cost and complication involved unless pressures approaching the critical pressure are eventually used in industrial plants.

Prime-Mover Characteristics.—Seventy-three per cent. of the units included in this survey are back-pressure machines. The remaining 27 per cent., having 38 per cent. of the total capacity, are equipped with condensers; these condensers are usually small, in some instances designed for less than 15 per cent. of the maximum throttle flow.

Of the condensing machines, only one 500-kW unit is non-extraction. The latter, however, operates in parallel with a larger machine exhausting at 40 lb. and the two units in this plant are, therefore, the equivalent of a condensing extraction machine. One large unit now under construction, which may operate at a pressure of 500 lb. or more, is a straight condensing machine with extraction only for feed-water heating.

Extraction pressures range from 5 lb. to 400 lb.; 38 turbines are arranged for single extraction, 15 for extraction at two pressures, and one is a mixed-pressure dual-extraction machine. The available information does not disclose any machine with more than two fixed-pressure extraction connections, or any back-pressure machine which has two. In some plants, however, high back-pressure units top lower-pressure extraction machines not included in the scope of this survey, and some high-pressure machines in the same plant are designed for extraction or exhaust at different pressures, so that by-product power is generated at several different levels. In one plant at least seven process pressures are provided by exhaust or extraction from different prime movers, the pressures ranging from a few inches of vacuum to 400 lb.

Steam-Generating Equipment.—The adoption of high pressures was accompanied by a simultaneous revolution in boiler design. For the earliest installation included in this survey, the boilers were designed to produce 22·5 lb. of steam per square foot of boiler heating surface, including the water-cooled furnace. The average heat input to the boiler, furnace walls, and economiser combined was 11,500 B.Th.U. per square foot per hour. These steam generators were installed in what was then one of the largest and most efficient industrial boiler plants in the country. In the old plant the maximum steam output was 4·15 lb. per square foot of boiler surface, and the average heat input was 3,100 B.Th.U. per square foot of total surface, including the economisers. Obviously, the new steam-generating equipment presented operating problems which had no relation to pressure, in spite of the fact that only condensate was used for feed-water.

Many of the high-pressure installations designed between 1928 and 1933 followed the more conservative design of earlier low-pressure boilers, but all of the more recent installations for which data are available have rates of heat transfer which would have been considered excessive 15 years ago, although they are lower than current central-station practice. Sixteen recently installed industrial boilers, operating at 600 lb. to 850 lb. pressure and ranging in capacity from 65,000 lb. to 500,000 lb. per hour, show a weighted average heat input of 9,200 B.Th.U. per square foot of total surface, including boilers, waterwalls, and economisers. The corresponding figure is 16,000 B.Th.U. per square foot for six utility-plant boilers, operating in the same pressure range, with individual capacities of 140,000 lb. to 575,000 lb. per hour, but with the same total capacity as the 16 industrial boilers. The lower average rate of heat input for the industrial boilers is due chiefly to the general use of treated water for boiler feed, and the higher concentration of solids in the circulating system.

Reciprocating Engines.—In 1925, there was some reason for expecting that many of the smaller high-pressure industrial power developments might utilise reciprocating engines for prime movers. This expectation has not been realised, due principally to the present high efficiency and reliability of back-pressure turbines even in relatively small sizes. The above-mentioned engine generator installation at Lockland, Ohio, has been in successful operation for several years, using steam at 1,650 lb. and 810 deg. F., and there is no mechanical reason why steam engines could not be used with very high steam pressure and temperature. However, the water rate of these engines is no better than the water rate of a present-day non-condensing turbine of the same size and the radiation losses are appreciably higher; also more frequent and more extensive outages are required for inspection and maintenance. No 500-lb., or higher, engine drives have been used for variable-speed equipment, such as compressors and pumps, although for this service the engine has a materially lower water rate than the turbine at partial loads and reduced speeds. Several thousand horse-power of engine drives have been installed, operating at pressures up to 450 lb. and temperatures up to 750 deg. F., but all of these installations were made before 1932 and there has been no recent progress in this direction.

Boiler Feed.—It was recognised in 1925, that the boiler feed-water supply would be a serious problem in high-pressure industrial plants, on account of the large percentage of make-up usually required. Tremendous progress has been made in the art of boiler feed-water purification, but it is still the major problem for high-pressure industrial work where condensate is not returned from the process. The claim is made that any natural fresh water can be chemically treated for any boiler conditions. While this statement may be technically true, its realisation may require large expenditures for equipment and always requires an advanced operating technique to maintain satisfactory results when poor water is treated for high pressure.

Table of Operating Results of High-Pressure Plants.

Total Installed Capacity:—	
Boilers, lb. per hour	2,535,000
Generators, kW (name-plate rating)	77,500
Total number of prime movers	13
Total number of boilers	14
Total Generation for 12 Months:—	
Steam, lb.	14,836,966,000
Power, kWh	458,275,250
Total of Individual Maximum Demands:—	
Steam, lb. per hour	2,294,000
Steam, per cent. rated capacity	91
Power, kW	76,970
Power, per cent. rated capacity	99
Load and Capacity Factors:—	
Ratio, average output to maximum demand—	
Steam	74
Power	68
Ratio, average output to rated capacity—	
Steam	67
Power	68
Availability:—	
Total outage, all prime movers, hours	12,807
Average outage per unit, hours	986
Average availability of prime movers, per cent.	89
Total outage, all boilers, hours	16,329
Average outage per boiler, hours	1,166
Average boiler availability, per cent.	87
Overall Thermal Efficiency:—	
Total net output as power, kWh	379,429,000
Heat equivalent of net power output, million B.Th.U.	1,296,000
Total net output as process steam, lb.	11,758,644,000
Heat equivalent of net steam output above heat in returns and make-up water, million B.Th.U.	11,160,000
Total net output, million B.Th.U.	12,456,000
Total fuel consumption, million B.Th.U.	16,426,000
Overall thermal efficiency, per cent.	76
Average heat consumption for power generation only, B.Th.U. per net kWh	4,780
Yield of By-Product Power:—	
Gross kWh per 1,000 lb. steam generated	31
Net kWh per 1,000 lb. steam delivered	32

The highest-pressure boiler in the group is fed with treated water, but ten of the twelve plants operating at pressures above 1,200 lb. use condensate exclusively. The energy loss which results from the use of evaporative condensers is less than is commonly supposed, and the cost of evaporators is partly offset by savings in cost of steam-generating equipment, due to the possibility of using less heating surface and smaller drums when pure feed-water can be assured.

Reserve Capacity.—One of the outstanding features of recent industrial-plant design is the willingness of the owners to rest factory production wholly or partially on a single boiler or turbine unit. For low-pressure plants of the type prevalent in 1925, it was axiomatic that there must be a sufficient number of boilers to enable one to be out of service for inspection or repairs at any time without curtailing production. There are relatively few of the modern high-pressure installations where this reserve has been provided, but the results have been reasonably satis-factory.

Of the 85 plants included in this survey, 29 have a single high-pressure boiler. In some cases, older low-pressure boilers relay the high-pressure equipment, but in others, factory production must be curtailed during outages. Some confusion arises in comparing costs of generated and purchased power when this absence of relay capacity is not taken into consideration. The ability of some industries to operate satisfactorily without relay capacity has stimulated an interest on the part of public utilities in designing

competitive rates based on interruptible service, which is the only type of service comparable with that provided by the majority of the plants in this group.

Operating Results.—In the discussion, 15 years ago, pessimism was frankly expressed regarding the ability of industrial operating personnel to handle high-pressure equipment. Experience has proved these fears unfounded, and such difficulties as have arisen have been with equipment, water and fuel, rather than with men. A few installations have been disappointing with respect to yield of by-product power and overall costs, and several have failed to develop the design capacity, but the majority have shown high thermal efficiency and high availability when operated within their actual capacity. The term "actual capacity" is used in contradistinction to the design capacity or manufacturers' ratings. In the Table on page 297, the composite results for six plants indicate the availability and efficiency obtainable in well-designed, competently-operated plants.

The plants included in this Table are not hand-picked to show favourable results, but include all of the plants for which the author had sufficient information to compute availability factors and efficiency. The availability of boilers and prime movers is not far different from the corresponding figures published by the Edison Electric Institute for high-pressure utility plants. Oddly enough the general average is lowered appreciably by the one plant which has reserve capacity, and in which plenty of time was available for inspection and repairs.

Installation Costs.—Construction costs vary widely and the cost of any single installation has little significance because of the extreme differences in conditions. In many cases the new equipment is installed in existing buildings or on sites where existing coal-handling facilities and water supplies can be utilised with a considerable saving in first cost. The following composite costs, however, for 13 back-pressure installations may be of interest. These plants range in capacity from 2,000 kW to nearly 100,000 kW, and all are designed for throttle pressures between 600 lb. and 850 lb. The costs include all of the equipment installed, together with such building alterations or extensions as the individual jobs required, and in several instances complete new buildings.

Total steam-generating capacity, lb. per hr.	5,885,000
Total electric-generating capacity, kW...	186,900
Total cost, dols.	22,832,000

The weighted average of costs is approximately 2 dols. per pound per hour of steam-generating capacity, plus 60 dols. per kilowatt of electric-generating capacity. This formula, however, applied to any individual installations, may be in error by as much as 35 per cent., and the fact that some were built during low construction cost periods makes them unreliable for present-day use. Steam-generating capacity should not be confused with net delivery to process mains, and it should be remembered that the large ratio of steam generation to power output results in an auxiliary power consumption which appears high when compared with central stations. On a net-output basis, the average cost for the foregoing plants would be approximately 2.50 dols. per pound of steam per hour, plus 72 dols. per kilowatt. For individual plants the steam factor ranges from 1.48 dols. to 3.57 dols. per pound, and the electric factor from 38 dols. to 123 dols. per net kilowatt.

The average excess cost of the complete plants over the estimated cost of plants designed to deliver the same quantities of low-pressure process steam only is about 105 dols. per net kilowatt, a figure which is less than the estimates made 15 years ago, largely because greater economy of boiler design has offset higher costs of labour and material. None of the plants included in this composite cost has any relay capacity, either steam or electric, and this fact should not be overlooked in a consideration of the costs.

Production Expense.—Available figures on production expense are even more unsatisfactory for comparative purposes than the installation cost data, due to variations in operating conditions and book-keeping methods. The best statement which the author is able to make, based on the limited data available, is that in moderate-sized plants operating at a good load factor, the production cost of 1,000 lb. of steam and 30 kWh from fuel, costing 15 cents per million B.Th.U., ranges from 29 cents to nearly 40 cents. This is bare operating expense, exclusive of depreciation, taxes, or interest on investment, and the units are net deliveries to manufacturing departments, not gross generation.

How these costs are divided between steam and power is a matter of bookkeeper's choice. If power generation is charged only with the reduction of enthalpy of the steam as it passes through the prime movers, it results in what appear to be very low power costs. If power generation is charged with the available energy extracted from the steam, the computed cost will be very much higher.

LABOUR NOTES.

The Ministry of Labour Gazette states that in the industries for which statistics are regularly compiled by the Ministry of Labour and National Service, the changes in rates of wages reported to have come into operation in August are estimated to have resulted in an increase of about 120,000*l.* in the weekly full-time wages of about 1,060,000 workpeople and in a decrease of about 13,000*l.* in those of 190,000 workpeople. The workpeople whose rates of wages were reduced had received increases of greater amount in earlier months of the year. The changes so far reported in the eight completed months of 1940 in the industries for which statistics are available are estimated to have resulted in a net increase of about 1,700,000*l.* in the weekly full-time wages of about 7,450,000 workpeople.

The principal groups of workpeople whose wages were increased in August included coal miners in Derbyshire, Nottinghamshire, Leicestershire, North Staffordshire, Warwickshire, Cannock Chase, and Scotland, brick makers, pottery workers, workpeople employed in the iron and steel manufacturing industry in various districts, tin-plate workers, tobacco workers, printing trade operatives, vehicle builders, and workpeople employed in rubber manufacture. The workpeople whose wage rates were reduced were mainly coal miners in Northumberland and Yorkshire.

The number of insured persons, aged 16 and over, recorded as unemployed in Great Britain and Northern Ireland at August 12, 1940, represented 5·4 per cent. of the total number of insured persons between the ages of 16 and 64 at July, 1939, as compared with 5·6 per cent. at July 15, 1940. At August 14, 1939, the corresponding percentage was 8·5. For persons insured under the general scheme, the percentages were 5·5 at August 12, 1940, as compared with 5·7 at July 15, 1940, and 8·7 at August 14, 1939. For persons within the agricultural scheme, the percentages were 2·4, 2·5 and 3·9, respectively.

At August 12, there were 613,156 persons on the registers of Employment Exchanges in Great Britain who were out of a situation. This was 23,376 less than at July 15, 1940, and 354,952 less than at August 14, 1939. There were registered as unemployed in Great Britain 154,380 persons who were on short time or otherwise temporarily suspended from work. This was 1,138 more than at July, 1940, but 57,598 less than at August 14, 1939. Of unemployed persons who normally seek a livelihood by means of jobs of short duration, there were on the registers in Great Britain 31,916. This was 5,576 less than at July 15, 1940, and 19,690 less than at August 14, 1939. The total of 799,452 persons on the registers at August 12, 1940, included 619,507 applicants for unemployment benefit or allowances and 179,945 non-claimants.

The number of trade disputes involving stoppages of work reported to the Ministry of Labour and National Service as beginning in August, was 50. In addition, two disputes which began before August were still in progress at the beginning of that month. The approximate number of workpeople involved in these 52 disputes, including workpeople thrown out of work at the establishments where the disputes occurred, was about 7,000, and the aggregate duration of the disputes in August was about 13,000 working days.

In its report to this week's Trade Union Congress at Southport, the General Council stated that its efforts in conjunction with those of representatives of the employers to reach a joint agreement on economic problems relating to the war had failed. It had invited prominent economists, including Mr. J. M. Keynes, to discuss the subject with them, and, as a result, it had drawn up a five-point programme for consideration by it and the employers. The points included (1) That it was undesirable that there should be substantial increases in prices during the war. (2) That no attempt should be made to restrain legitimate increases of wages due to any rise in the cost of living. (3) The Government should be urged to continue its price control policy and extend the range of subsidies as far as practicable. (4) An appeal should be made to the people of this country to save to the utmost of their capacity and invest the savings in Government stocks, shares, etc., on the clear understanding that these savings would not subsequently be used to penalise the persons concerned in either future applications for wage advances, or in the granting of unemployment or public assistance, should they subsequently become unemployed. (5) It should be stated in the clearest possible language that unreasonable profits secured during the period of the war were gravely detrimental to the interests of the country.

Continuing, the General Council's report stated that meetings were held with representatives of the Employers' Panel of the National Joint Advisory Council, in order that these points should be expanded into a memorandum for joint issue. In the end, however, the developments of the war situation and the difficulties of agreeing to a joint statement "upon so thorny and contentious a subject, including among other matters the question of wages policy," proved insurmountable, and, in fact, no such joint statement was issued.

In view of the importance of stimulating the training of women in various branches of the engineering industry for war work, the Minister of Labour and National Service has arranged with the Central Electricity Board for the release, on a part-time basis, of Miss Caroline Haslett, to act as adviser to the Ministry on women's training. Miss Haslett is president of the Women's Engineering Society.

At a meeting in London on Wednesday last week, the colliery owners' Central Committee approved the scheme for a levy of 6*d.* a ton on all disposable coal in order to form a fund to compensate colliery undertakings suffering loss of trade through the war, or damage interfering with production by direct enemy action. According to the Labour correspondent of *The Times*, on an output of 200,000,000 tons a year, the levy would produce 5,000,000*l.* It has been estimated, he says, that the cost of keeping collieries on "a care and maintenance basis" is the equivalent of 2*s.* 6*d.* a ton of normal output. The colliery districts which have suffered most severely from loss of overseas markets are South Wales and Durham. Northumberland has been able to make good part of its loss by selling in the home market where large stocks are being built up.

The Executive of the Dominican Republic is authorised to issue decrees, regulations and instructions necessary to ensure to the working classes in agriculture and industry a wage compatible with the cost of living. The law provides for the appointment, by the Executive, of a National Committee for the Regulation of Wages which will recommend to him, when it deems such action necessary, minimum wage rates for every kind of agricultural and industrial work performed in the Republic and the form in which the wages are to be paid, taking into consideration (1) the kind of work and the conditions, time and place in which it is done; (2) the current price of the article produced; and (3) the average cost of living to the worker.

The committee is to be composed of two Government officials (representing the Secretariat of Agriculture, Industry and Labour, and the Secretariat of Treasury and Commerce, respectively), one agriculturist, one industrialist, and one merchant, as permanent members; and in addition, two members of the chamber of commerce, or their representatives, from the region interested in the wage scale under consideration, as temporary members but having voice and vote. The Executive shall choose from the permanent members a person to preside, and shall also designate a secretary without voice or vote. The decision reached by the committee shall be carried out only after decree by the Executive. Fines are prescribed for violation of the legislation affecting the minimum wage, and of the wage rates established. Collection of fines is entrusted to the mayors of the communes within which the industries concerned are established or the work is done. Certain authorities are designated to enforce the minimum-wage legislation.

Minimum wage rates, effective for three years, for adult workers in Brazil, without distinction of sex, vary from 3,600 to 9,600 milreis per day, according to locality, under a decree-law of May, 1940. Minors under 18 years of age are to be paid half the adults' rates and specified increases are to be allowed to persons engaged in operations considered to be unhealthy. This legislation constitutes an extension of the provisions of the decree-law of January 14, 1936, which was regulated by one dated April 30, 1938. The wage is stated to be "capable of satisfying, under present conditions and in sections of the country specified in an annexed table, the normal needs of food, shelter, clothing, sanitation, and transportation." The rates established may be modified or extended for successive periods of three years each; but if, during a three-year period, circumstances arise which, in the opinion of three-fourths of the members of the commission, materially affect living conditions, the wage may be revised. The present rates went into effect 60 days after May 4, 1940, the date of publication in the Diario Oficial.

PRACTICAL BLAST-FURNACE MANAGEMENT IN SOUTH AFRICA.*

By R. R. F. WALTON.

THERE are two blast-furnace plants in South Africa: the Pretoria plant of the South African Iron and Steel Industrial Corporation, Limited, and the Newcastle plant of its associated company, African Metals Corporation, Limited. The Pretoria, or Iscor, plant consists of two primary and two secondary crushers, with duplicate conveying belts, so that either primary crusher can work with either secondary crusher and deliver crushed ore and flux via either conveyor. The crushers are of the gyratory type, and can handle 500 tons of ore per hour. The crushed material is elevated to a transfer bin, from which it is drawn into electric transfer cars and dumped into the furnace bins or the ore-trough, from which it is handled on to the stock piles by means of a rope-trolley type ore bridge. The bins are of reinforced concrete. The furnace charging is carried out by double skips, electrically driven, on an inclined hoist. Coke is drawn from coke bins on either side of the hoist into automatic weigh hoppers, which deliver into the skips. Ore and flux are handled in electric scale cars of 10 tons capacity. The scale-car driver operates the whole of the charging system.

There are two furnaces, each of the following dimensions :—

Height from hearth to top platform ...	86 ft. 6 in.
Hearth diameter	16 ft. 1 in.
Bosh diameter	19 ft. 6 in.
Throat diameter	14 ft. 0 in.
Bell diameter	10 ft. 0 in.
Height of bosh	10 ft. 6 in.
Height of parallel section above bosh	7 ft. 0 in.
Depth of parallel section below platform	19 ft. 0 in.

Fig. 1, on this page, shows the lines of these furnaces. The furnaces are equipped with McKee revolving tops. Hearth cooling consists of solid-drawn steel pipes cast in cast-iron staves, surrounded by a 1½-in. mild-steel jacket. The bosh is of the banded type, cooled by copper plates, while the tuyere belt is a 1-in. mild-steel jacket pierced to take ten tuyeres and four rows of cooling plates. There are seven rows of duplex copper plates above the lintel. The metal is handled via cast-iron runners into 60-ton ladles, while two slag notches are provided. These consist of a cast-iron cooler with steel-pipe coil cast in, an intermediate copper slag cooler and a 2-in. copper monkey. The slag is delivered into steam-tipped slag-ladles of 175 cub. ft. capacity. An electric passenger lift is provided for access to the furnace tops.

There are five two-pass stoves, 21 ft. by 105 ft., filled with Strack zoned chequers. No. 3 stove is arranged so as to be capable of being used on either furnace. This equipment allows of a blast temperature of 1,600 deg. F., using about 20 per cent. of the gas produced. The usual snort- and mixer-valves are incorporated in the blast mains. The gas is drawn off by four off-takes, joining into two down-comers, which deliver in each case into a 30-ft. plain dust catcher, followed by a Vortex dust catcher which removes about 60 per cent. of the remaining dust. The gas next passes into a pre-cooler and then into the common cool-gas main, from which it is passed into either the Lodge-Cottrell gas cleaner, which is a three-unit two-stage plant, or into two tower washers followed by three Theisen disintegrators. One Lodge-Cottrell unit and one Theisen disintegrator are spares, the remaining units being sufficient to handle all the gas from two furnaces and clean it to 0·0070 grain of dust per cubic foot. The clean gas is delivered into a 2,000,000-cub. ft. gas-holder of the waterless type.

Normally molten metal is delivered directly to the melting shop, but, when necessary, the whole output can be handled in a two-strand pig-casting machine. The water service is duplicated to each furnace and efficient strainers are provided.

The Newcastle plant, situated in Northern Natal, about 220 miles from Pretoria, consists of one blast-furnace having the following dimensions :—

Height	70 ft. 0 in.
Hearth diameter	10 ft. 0 in.
Bosh diameter	14 ft. 5 in.
Throat diameter	10 ft. 0 in.
Bell diameter	6 ft. 0 in.

The hearth and bosh jackets are of mild steel, cooled by external sprays. In the mild-steel tuyere belt there are eight tuyeres and three rows of copper plates. There is one row of copper plates above the lintel. The furnace lines are shown in Fig. 2, on this page. This furnace is charged by means of barrows carried by a double-cage vertical hoist. Most of the materials

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Fig. 1. Nos. 1 & 2 ISCOR

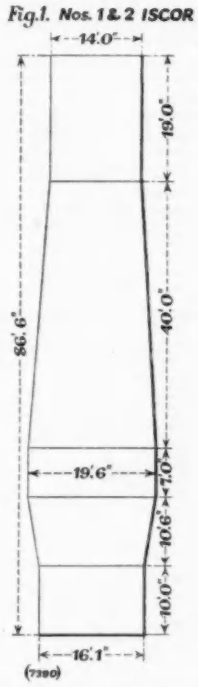
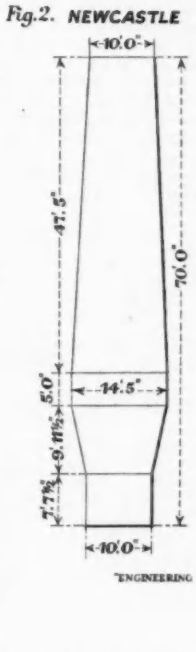


Fig. 2. NEWCASTLE



duction of iron from exceedingly rich ores with poor coke. At Pretoria, the usual ore mixture contains 64 per cent. of iron and 6·1 per cent. of silica, while the coke contains 16 per cent. of ash and only 82 per cent. of fixed carbon. About 3,050 lb. of ore and 1,530 lb. of coke are required to produce a short ton of metal. It will be seen, therefore, that the greater proportion of the slag-forming materials arises from the coke, and as this is only liberated when combustion of the coke takes place, there can be no comparison between the slag in the bosh zone and the final slag flushed from the furnace. It might be expected that

TABLE I.

Constituent.	Thabazimbi ore.	Pretoria ore.
	Per cent.	Per cent.
Iron	66·6	50·0
Silica	3·5	20·0
Alumina	0·5	4·0
Lime	0·1	0·3
Magnesia	0·1	0·2
Manganese	0·20	0·2
Phosphorus	0·025	0·1

the extremely limey slag at the top of the bosh would cause trouble, and that this is not so is partly due to the small weight of slag arising from the ore-bearing materials. Fortunately, the two ores used contain 0·5 per cent. and 4 per cent., respectively, of alumina, so that it is possible to balance the two to produce a slag containing about 16 per cent. of alumina, which gives a very free-flowing slag.

Iscor Works.—The two ores used at Iscor are Thabazimbi and Pretoria ore. The former is transported about 155 miles, while the latter is quarried on the property. Average analyses are given in Table I. Both ores are extremely dense, more especially the Thabazimbi ore, and are therefore crushed to 2½ in. maximum. No grading of the ore is carried out at present, but plant is being installed to carry out furnace tests on graded burdens. Because of the hard and abrasive nature of the ores, regular attention must be given to the crushers, which are re-set as wear takes place and re-metalled or renewed as occasion requires.

Both dolomite, obtained close to the works, and calcite are used as flux, the usual proportion being 65 per cent. of dolomite and 35 per cent. of calcite. Each flux has been used alone successfully, but the dolomite gives a more freely flowing slag. Average analyses are given in Table II. These fluxes are also crushed to 2½ in. maximum and used without screening.

TABLE II.

Constituent.	Dolomite.	Limestone.
	Per cent.	Per cent.
Silica	2·8	1·0
Alumina plus ferric oxide ..	2·1	0·7
Lime	29·3	48·5
Magnesia	19·6	5·5
Manganese oxide	1·0	—

The coke produced from Transvaal coals is high in ash—about 16 per cent.—due to difficulties in washing, brought about by the density of the coal and the discard being very much the same. It has a low abrasive index, and about 15 per cent. is screened out as breeze below 1 in. and used elsewhere on the works. The coke is screened as it falls into the weigh-hoppers ready for charging, and all less than 1 in. material is rejected. Actual furnace tests carried out at Iscor to determine the value of this breeze gave the figures in Table III, after making allowance for runner and casting-machine scrap returned to the furnaces. Table III confirms the experience of other operators that coke below 1 in. has no furnace value. As so great a proportion of the slag arises from the coke ash, it is necessary to keep a careful watch on the weight and ash content of the coke, because any difficulties at the washery or coke-ovens are at once reflected in the slag composition. The coke is dry quenched, and can therefore be charged by weight when received directly from the ovens. If stock coke has to be charged, the moisture content must be known and allowed for.

TABLE III.—*Furnace Tests to Determine the Value of Coke Breeze.*

Test No.	1.	2.	3.
Furnace No.	2	2	2
Period, days	21	21	21
Coke size, in.	+½	+⅜	+1
+ 1 in. coke, lb. per ton of metal ..	1,675	1,630	1,635
⅜ to 1 in. coke, lb. per ton of metal	—	92	—
½ to 1 in. coke, lb. per ton of metal	89	—	—
Total coke, lb. per ton of metal ..	1,764	1,728	1,635
Silicon in metal, average, per cent.	0·84	0·91	0·83
Sulphur in metal, average, per cent.	0·031	0·027	0·028
Blast pressure, average, lb.	15·44	13·45	12·50
Average hours per day when blast pressure was over 17 lb. ..	1·53	1·20	Nil

Newcastle Works.—The iron ores used at Newcastle are Thabazimbi ore and ores from local surface deposits. The latter vary from 50 per cent. to 58 per cent. of metallic iron, with from 6 per cent. to 10 per cent. of silica, and are limonites. It is necessary to add sandstone to mixtures of these ores to produce a sufficient slag volume for effective desulphurisation, but this presents no difficulty. The distance from Thabazimbi to Newcastle is about 375 miles, while the local ore deposits are at an average distance of 30 miles. Transvaal dolomite, similar to that used at Iscor, is the regular flux, while for phosphoric foundry irons, with up to 1·6 per cent. of phosphorus, phosphate rock is added to the burden. The coke used is beehive and by-product coke produced in Northern Natal, and delivered to the works by rail. The average analysis is approximately :—Fixed carbon, 84·1 per cent.; ash, 13 per cent.; sulphur, 0·9 per cent.; and moisture, 2 per cent. For the production of ferro-manganese the same coke and dolomite are used with manganese ore from the Postmasburg district of the Cape Province. The latter averages 50 per cent. of manganese, 7 per cent. of silica, and 5 per cent. to 6 per cent. of iron, and is in dense lumps, which are broken to about 5 in. size for blast-furnace use. The usual 78 per cent. to 80 per cent. alloy is produced, the consumptions of raw materials being approximately :—Manganese ore, 4,000 lb.; coke, 4,850 lb.; and dolomite, 2,100 lb. per ton of alloy. The output of foundry iron of all grades averages about 140 tons a day and of ferro-manganese 63 tons a day.

Weighing Appliances, Stoves and Gas-Cleaning Plants.—Coke weigh-hoppers and scale cars must be kept in good order and are checked regularly. In addition,

scale-car drivers are required to report immediately the zero adjustment of the indicators is found not to be correct. A weekly check on the input and output of metallic iron will at once reveal any inaccuracy in the weighing apparatus. A daily inspection of all wearing plates in the weighing apparatus, skips and small bell hopper is carried out. Spare wearing plates, standardised so far as possible, are carried, so that replacements can be made promptly.

Care must be taken when using clean gas and pressure-burners that the stoves are not overheated. At Iscor a thermocouple is inserted in the dome of each stove and a continuous record taken of the temperature. Stove attendants are instructed not to allow the dome temperature to exceed 2,100 deg. F. With stoves of sufficient capacity this is ample to maintain a blast temperature of 1,600 deg. F. when required. All valves are examined regularly in order to see that they are seating tightly and that the water supply to hot-blast and chimney valves does not fail. Feed-pipes and valves, where water-cooling is used, are flushed out regularly, especially in flood conditions, when the water may carry high concentrations of solids in suspension. The waste gases are tested about once every other week and the combustion is adjusted to ensure that only the minimum volume of gas is used, leaving as much as possible available for other parts of the works. A volume indicator, showing the amount of gas being burnt in the stoves, is fitted at Iscor; it is a useful check on the efficiency of the combustion.

The Lodge-Cottrell plant depends for its efficient operation on the temperature and humidity of the gas it has to treat. A thermostat and regulator govern the supply of water to the precoolers, and it is essential that the bulb of the thermostat be kept clean. At Iscor it was placed originally in the vertical main from the precooler to the cool-gas main. In this position it was found impossible to keep it free from mud, so that it was removed to a position in the cool-gas main, with very beneficial results. A recorder showing the cool-gas temperature is placed in a convenient position, so that the operators know that the regulator is functioning properly. Both precooler and slat-tower sprays are of such a type that they can be withdrawn individually and cleaned during operation, and this should be done each shift. Fans and treaters should be taken off in rotation at regular intervals for cleaning and overhaul. Feed-pipes for the water supply for both tower washers and Theisen disintegrators are duplicated so far as possible, as constant recirculation of the water causes increased solids both in solution and suspension, and these build up in the water pipes. The seals of the disintegrators are flushed out daily and the machines taken off for cleaning and inspection at regular intervals. All gas mains have suitable drains delivering into seal pots. These are flushed out weekly. Suitable connections on the mains are provided so that they can be swilled out with water into these seal pots. It goes without saying that dust catchers are emptied daily, and not allowed to accumulate dust.

(To be continued.)

CATALOGUES.

Anti-Vibration Mountings.—We have received a booklet, issued by Messrs. Silentbloc, Limited, Victoria-gardens, Ladbroke-road, Notting Hill Gate, London, W.11, which gives particulars of some applications of their mountings to meet special requirements.

Machine-Tool Performance Data.—From time to time, Messrs. Gisholt Machine Company, Madison, Wisconsin, U.S.A., publish data sheets relating to the performances of turret and automatic lathes, etc. The latest series received includes a typical example of static-dynamic balancing on a Dynetric machine.

Rotary Screw Pumps.—In referring in this column, on page 180, *ante*, to a catalogue issued by Messrs. Mirrlees, Bickerton and Day, Limited, Hazel Grove, near Stockport, describing the "Mirrlees-Imo" positive rotary screw pump, we omitted to mention that the pump is mainly used for handling oil of various viscosities at a wide range of pressures.

Sparking-Plug Cleaner.—Messrs. B.E.N. Patents, Limited, High Wycombe, Buckinghamshire, have sent us leaflets describing the redesigned form of their sparking-plug cleaner. This device uses compressed air to blow a special cleaning compound on to the plug, and is supplied with a detachable blow gun for connection to an air supply at 100 lb. to 150 lb. per square inch pressure.

Concrete Reinforcement.—We have received from Messrs. Spungrove, Limited, 7, Princes-street, Westminster, S.W.1, a brochure containing data relating to their high-tensile steel reinforcement for concrete. Illustrations show how the material is used and tables are included giving details of sizes, weight and loading, based on working stresses of 750 lb. per square inch in the concrete and 25,000 lb. per square inch in the reinforcement.

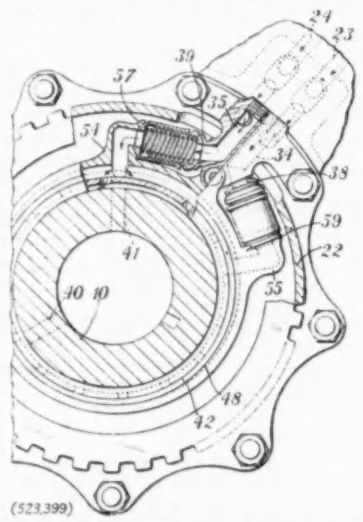
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

523,399. Hydraulic Fluid-Transmission Joint. The Bristol Aeroplane Company, Limited, L. F. G. Butler, and W. Cordiner, of Bristol. (5 *Figs.*) December 2, 1938.—The invention relates to a transmission joint for conveying hydraulic fluid to the blades of variable-pitch airscrews, which accommodates and is unaffected by slight misalignment, tilting and endways movement between the two parts. The airscrew shaft 10 is driven through a number of planet gears, which each mesh with a fixed bevel gear splined on a ring 22 bolted to the gear-casing, which is mounted in front of the engine crankcase. In the gear-casing are formed two conduits 23, 24, which register respectively with holes in the flange of the ring 22. A T-shaped member is formed with passages 34, 35, which diverge at the inner end, each opening into a concave spherical seating 38, 39. The shaft is drilled with two radial ports 40 and 41, which are relatively displaced angularly and axially. Surrounding the shaft is a bush 42 having two continuous



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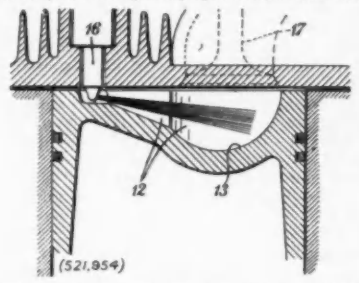
internal grooves, each registering with one of the ports. The bush is surrounded by a sleeve 48, which is formed with continuous internal grooves communicating with the grooves in the bush. The sleeve 48 is formed with two integral lugs 54, 55. Internal passages in the lugs open at the inner end into the grooves in the sleeve and at the outer end into concave spherical seatings 57 and 59. The spherical seatings 57 and 39 are connected together by an extensible coupling consisting of an outer sleeve, and an inner tube sliding within it, the sleeve and tube having spherical ends to fit the seatings 57 and 39, respectively. The sleeve and the tube are pressed apart by a compression spring. The spherical seatings 59 and 38 are similarly interconnected, so that the sleeve 48 is held against rotation by the couplings. The bush 42 rotates with the shaft. Hydraulic fluid for varying the pitch of the airscrew blades in one direction is admitted to the conduit 23, from which it passes through the extensible coupling and grooves in the sleeve and the bush to the port 40, and thence through the shaft to the blades. The fluid returns through the other port 41 and conduit 24. (*Accepted July* 15, 1940.)

INTERNAL-COMBUSTION ENGINES.

521,954. Heavy-Oil Engine. R. A. Lister and Company, Limited, of Dursley, and J. R. Thonger, of Dursley. (12 *Figs.*) November 29, 1938.—The invention is a cavity piston for a heavy-oil compression-ignition engine. The under surface of the cylinder head is flat and the piston head at top dead centre leaves only so much clearance as is mechanically necessary. The cavity 12 in the piston head is of half-pear shape, the end portion 13 being part spherical, and its centre line lying on a diameter of the piston head. The injector 16 is mounted in the cylinder head with its delivery end just above the shallow, narrow end of the cavity, the nozzle opening being on one side so that, when the piston is at top dead centre, the oil is sprayed along the centre line of the cavity towards the part-spherical end 13. The inlet and exhaust valves 17 are arranged on opposite sides of the centre line of the cavity, their axes and that of the injector being fairly symmetrical with respect



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to the cylinder bore. The valve heads are within the boundary of the piston circumference, and their disposition and dimensions are not restricted by the position of the injector, but they must not be on the fuel-injector side of the diameter drawn at right angles to the axis of the cavity. As the piston approaches top dead centre, the air in the clearance volume on opposite sides of the cavity is forced inwards towards the cavity, and these two air streams meet and swirl towards the bottom of the cavity and round by the sides. The oil spray, which is fairly long, is therefore enveloped by a layer of air and insulated from contact with the piston surface. (*Accepted June* 5, 1940.)

MISCELLANEOUS.

517,795. Concrete Mixer. Winget, Limited, and C. W. Stancliffe, of Rochester, Kent. (4 *Figs.*) August 6, 1938.—The invention is a unidirectional drive for concrete mixers. A concrete mixer used in road work is usually placed some distance from the road bed and the concrete is wheeled from the mixer to the road bed. The mixer has to be moved back at intervals as the work advances and cannot, for the most part, be very near the road bed unless it is moved at very short intervals, and since the mixer is heavy, this is undesirable. A unidirectional drive has, therefore, been designed in which a lever 2 is mounted on each of a pair of wheel hubs 3 and is bent up at its free end so that it can rest on the ground when not in use. The bent-up end can take a length of piping so that its effective length can be increased. The levers are connected together to drive both wheels at once.

Fig.1.

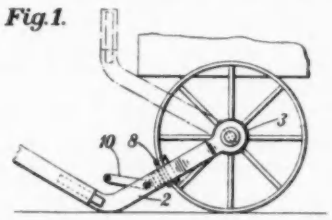
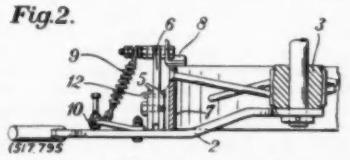


Fig.2.



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Each lever has a pair of projecting lugs 5 to which a link 6 is pivoted, this link spanning the width of the wheel rim 7. At the other end, the link 6 carries a grip 8 which engages the side of the rim on movement of the lever 2 in an anti-clockwise direction, the link 6 being thus tilted and drawing the grip towards the wheel. On movement of the lever 2 in the other direction, the grip slips relatively to the rim. The link 6 is locked in the central position with the grip out of contact with the rim by a pin 12 passed through the projections 5 and the link. The link 6 is maintained in its inclined position by a spring 9. One end of this spring is connected to the link 6 and the other end is connected to a short lever 10 pivoted to the lever 2. The ratchet mechanism is reversed by swinging this short lever about its pivot. The grip is double-ended, so as to rotate the wheel in either direction according to the position of the short reversing lever. If the levers 2 are connected by linkages to the charging hopper of the mixer, then on raising the hopper, the levers are raised, the grips slipping on the wheel rims. On lowering the hopper, the grips bite on the wheel rims and turn the wheels. Thus, at each discharge the mixer is moved a short distance and can be kept close up to the road bed. (*Accepted February* 8, 1940.)